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FROM NON MARKET ATTITUDES TO MARKET BEHAVIOR: LABORATORY EXPERIMENTS IN MOSCOW AND THE *HVATAT* PROPERTY OF HUMAN BEHAVIOR

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This paper[1] reports on laboratory market experiments that were conducted in Moscow during the fall of 1992. Two broad concerns guided the design of the experiments. The first concern is the obvious cultural differences between people in Russia and those in the west where traditional laboratory market experiments have been conducted. Most economists who have conducted experiments would assume that cultural background would not play a major part in the equilibration process, and that the law of supply and demand would operate essentially the same in all cultures and at all times. As Russia is undergoing a dramatic social change and before an orientation to market attitudes permeates the society, a unique opportunity presented itself to test this assumption about the universal nature of the laws of the market.

In the language of the experimenters, this first concern is whether or not some of the known properties of markets that operate in western culture are robust to major changes in the culture of the subject population. The properties of markets that are of interest are the fact of equilibration, the influence of price ceilings on equilibration and the influence of the asymmetries in the shapes of the demand and supply curves on the direction of convergence to equilibrium. The second concern reflects a desire to explore some more recently discovered aspects of market behavior. A transactions cost was added to the market and the question posed was whether or not the cost frustrated or biased equilibration (Jamison and Plott, 1997).[2]

The results of the experiments were not as anticipated. The standard convergence process was observed but when the data were applied to test the asymmetric rent hypothesis or the hypothesis regarding the nonbinding price controls, some surprises surfaced. In particular the data were not the same as had been observed in other experiments. This paradoxical failure of previous results to generalize prompted a detailed investigation into the behavior of individuals in the experiments. The hope was to find the causes of the

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[1]The financial support of the Caltech Laboratory of Experimental Economics and Political Science and of the National Science Foundation is gratefully acknowledged. We also want to thank John Patty for his helpful comments.

[2] Julian C. Jamison and Charles R. Plott, "Costly Offers and the Equilibration Properties of the Multiple Unit Double Auction Under Conditions of Unpredictable Shifts of Demand and Supply," *Journal of Economic Behavior and Organization* 32 (1997):591-612.

discrepancies. A special section of the paper is devoted to a conjecture that resulted from the ex-post examination of the data and is offered as an explanation.

The paper is organized as follows. In the first section the purposes of the project are outlined in greater detail. The second section contains the experimental design, procedures and parameters. The third section contains the predictions of alternative models as applied to the special case of the parameters of the experiments. The fourth section contains the results of the experiments. The fifth section contains the post experiment speculations about the possible explanations of the surprising dynamic behavior. Here the idea of *Hvatat*, which means "to grab" in Russian, is introduced and explored. The final section is a summary of conclusions.

1. AN OUTLINE OF PURPOSE

The differences between the east and the west that stem from the cultural and economic histories include differences in the a priori beliefs of researchers about the basic principles of behavior that lie beneath individual actions. The tendency of western scientists has been to rely on the competitive equilibrium model as a guide for what might be expected from markets. On the other hand Professors Menshikova[3] and Menshikov[4] have been close to the application and computation of cooperative game models of market-like phenomena. The existence of differences in modeling philosophy suggested the need for a conservative approach to experimentation. Thus the conservative research approach taken here was to first test to determine the capacity of the competitive model to predict the behavior of markets with Russian subjects. Thus the broad, research motivating questions are as listed below.

(i) Does the competitive equilibrium model have the ability to predict the markets with these subjects? Or, do the markets obey some set of principles completely unrelated to any of the standard market models?

(ii) Do the markets in Russia have some of the same empirical properties characteristics of the dynamics of the price adjustment process that have been observed in experimental markets in the west?

(iii) Do markets with Russian subjects converge to equilibrium from above when the consumer surplus is greater than producer surplus (as it does in market experiments conducted in the west)?

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[3]O. R. Menshikova, "On Computation of the Generalized Nucleolus," *USSR Computational Mathematics and Mathematical Physics* 16 (1976):1121-1135.

[4]O. R. Menshikova and I. S. Menshikov, The Generalized Nucleolus and a Solution of a Continuous Allocation Problem, IIASA, Laxenburg, Austria, 1983 .

(iv) Do nonbinding price controls have the same effect on the convergence process with Russian subjects as such controls do when experiments are conducted in the west?
(v) Do markets equilibrate in the presence of a "transactions cost" placed on bids and asks and do such transactions costs have the same influence on the markets with the Russian subjects as have been observed in the west?

The first properties are very prominent in the data in western markets. Equilibration is almost always observed and the process of equilibration has some distinct properties. Similarly, the asymmetry of rents has a pronounced effect on the direction of convergence as does the presence of nonbinding price controls. The research strategy was to test for properties of markets, the absence of which would be very visible and easy to detect without a large number of experiments. The idea was to pose very focused questions of the form "can the phenomena be detected in this subject pool" as opposed to "how big is the effect in this subject pool." The former question can be answered with fewer observations while the latter question may never be answerable given the limited resources available for research. The final question (v) is relatively new to the experimental literature and reported results have not been fully replicated.

2. EXPERIMENTAL DESIGN, PROCEDURES AND PARAMETERS

A total of thirteen experiments were conducted in Moscow. Subjects were drawn from five different subject pools. Three different institutional environments were studied. Each experiment had 10 subjects. A period zero was conducted in which subjects were not paid. After the period zero the aggregate parameters (but not individual parameters) were constant for ten periods after which demand was shifted upward unannounced. The experiment then continued for another 9 periods. The fact that these parameters were exactly the same across all experiments allows some comparisons of subject pool differences.

Demand and supplies were induced using standard procedures and stated in an experimental currency called francs. Subjects were all aware of the rates of conversion between the experimental francs and rubles (1f = .3 rubles). Incentives were substantial relative to those that have typically been used in experiments in the west. The average earnings from the experiments was about 1400 rubles which was about twice the monthly stipend of 720 rubles per month that students received and about one third of the monthly wage in November 1992 of 4200 rubles that was the salary of the typical adult that participated in the experiments.

Table 1 contains a listing of all experiments by subject pool and by treatment variables. The indexing numbers refer to the date on which the experiment was conducted. This manner of indexing the experiments is used throughout the text and in all records. All experiments were conducted through a local area network using the electronic multiple

unit double auction program[5] . This program follows the rules of the multiple unit double auction process outlined by Plott and Gray (1990)[6] including the rules that only the best bid and the best ask be exposed to the market.

The subject pools were as follow. A. Moscow University undergraduate students in applied mathematics. These subjects had no experience with any type of experimental market. B. Students from Moscow Institute of Physics and Technology. Students are admitted to this Institute only after having demonstrated exceptional abilities in the sciences. Several of the subjects were members of Professor Menshikov's class in which both games and markets had been discussed. Several knew about the double auction. C. Students from Russian Open University. These subjects were from adult education classes in business and applied mathematics. D. Mixed adults consisted of faculty and graduate students from the Moscow University. E. Teenagers. These teenage subjects were from a special school for talented students with age ranging from 13 to 15 years old.

The institutional environments were as follows. Four basic experiments were conducted. These experiments were the standard multiple unit double auction with no special institutional changes. Four additional experiments were conducted in which a nonbinding price ceiling was imposed on the market. Neither bids nor asks could be tendered for amounts above the ceiling. The ceiling was either 20 francs above the highest competitive equilibrium price (2 experiments) or 30 francs above that price (2 experiments). As will be explained along with the details of the experiment below, the ceiling was increased two periods before a demand shift (upward) so there are in each of the four price ceiling experiments, two periods in which the ceiling was either 60 or 70 francs above the highest competitive equilibrium price. Five experiments were conducted in which a tax was placed on all bids and similarly a tax was placed on all asks. No tax was placed on an individual who accepted a bid or an ask. The amount of the tax was either 4 francs (2 experiments),3 francs (two experiments) or 2 francs (1 experiment) and was the same constant amount independent of the number of units offered. That is, a bid of 1 unit cost the bidder, say 4 francs, and a bid of 5 units also cost the bidder 4 francs.

The parameters can be understood with the help of Figure 1, the aggregate demand and supply and Table 2, the individual redemption values and costs. The curves DD and SS existed before the shift at period 11 and the curves D'D' and S'S' existed beginning with period 11. The units are in experimental francs which were worth 0.3 rubles each. The upward shift in the curves is by 40 francs added to both the demand curve and the supply curve. As can be seen the consumer surplus is greater than the producer surplus. The ratio is 1.882.

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[5]Charles R. Plott," A Computerized Laboratory Market System and Research Support Systems for the Multiple Unit Double Auction," Social Science Working Paper 783, California Institute of Technology, November 1991.

[6] Charles R. Plott and Peter Gray, " The Multiple Unit Double Auction," *Journal of Economic Behavior and Organization* 13 (1990):245-258. North Holland.

While the aggregate demand and supply parameters were constant for several periods before a shift in parameters, the individual parameters were not constant. The incentives for each individual changed every period. An individual was either a buyer or a seller throughout the experiment. At the beginning of the period each individual was given a stapled "stack" of redemption values (buyers) or costs (sellers). At the end of a period the individual removed the top sheet to reveal the incentive chart for the next period. The incentive charts were grouped in "schedules ". Examples of such schedules are shown in Table 2.

Individuals were recruited by announcements in classes. They were told that they were going to participate in an experiment and that they would be paid. They were not told the amounts. When assembled, the individuals worked through a computerized instruction program that familiarized them with the keys and their functions in an electronic market. The instructions were all translations into Russian of instructions that are used in the west (Plott 1991).

After the instructions were completed the individuals participated in a period zero for practice. For this period they were not paid. After the practice period the records were checked carefully and confusion about the accounting were explained to subjects individually.

Period zero was 10 minutes. All succeeding periods were 5 minutes. If a price ceiling was in place it was imposed at the first of the experiment including period zero. The ceiling was then increased by forty francs in period 9.

In period 11 the second set of parameters came into existence. These new parameters were built into the stack of incentive schedules that the subject was given at the beginning. No announcement was made about the parameter change and all incentives were private information. Thus, given the method of giving incentives, the change could have easily gone unnoticed by the subjects.

3. COMPETITIVE MODEL AND PROPERTIES OF INTEREST

As shown in figure 1 the competitive equilibrium is [350, 360] for the first set of parameters and after the shift in period 11 to the second set of parameters the competitive equilibrium is [390, 400]. There are many competitive equilibrium prices in these ranges (10 francs) but there is only one equilibrium quantity. The price range reflects an acknowledgment of a transactions cost that is known to exist in markets. For purposes of analysis the middle of the price range will be treated as the prediction of the model. That is, the competitive equilibrium price prediction with a subjective transactions cost included is 355 before the shift and 395 after the shift.

Rent Asymmetry Property. It is well documented that when consumer surplus is greater than the producer surplus, prices tend to come into equilibrium from above the equilibrium price. Under the parameters of all expenses, the rate of consumers' surplus to producers' is 1.8.

Price adjustment dynamics. A few stylized facts have been produced about the nature of the convergence process in the double auction market. First, it known that the number bids relative to the number of asks will predict price movements. Secondly, the prices at which asks are taken tend to be above the prices at which bids are taken. The question is whether these known properties will reproduce in this subject pool.

Price ceilings. One of the paradoxes of experimental markets is that nonbinding price ceilings have an effect on the market. Ceilings placed above the equilibrium but near the equilibrium tend to make the prices approach equilibrium from below. The question posed is whether this property can be detected in the Russian subject population.

Transactions costs. Study of Table 2, reveals that the price "tunnel" is 10 francs. The tax on bids and asks was not sufficient to make marginal trades completely unprofitable unless the subjective transactions costs is 5 francs. However, the transaction costs do affect the search activity in a market. It is always in the interest of one side of the market to let the other side make a bid/ask of a given level. Results reported in the literature (Jamison and Plott 1997) hold that convergence to the equilibrium does occur but this needs to be checked. The possibility exists that the market could get "stuck" at prices removed from the competitive equilibrium because each agent does not want to bear the transactions cost and waits for someone else to do it. This type of public goods/ prisoner's dilemma could conceptually prevent convergence to the equilibrium of demand and supply. While the existing study reports price convergence, it also reports that the tax decreases the number of bids and asks and lowers efficiency. The question posed here is whether it has the same effect with Russian subjects.

Hvatat. In Russian *Hvatat* means "to grab". The concept is used to motivate a series of notions that will be introduced in the special section that follows the results. As will become clear in the results section, the markets do not behave exactly as expected and an the special section is an ex-post attempt to explain what happened and why.

4. RESULTS

The price time series of all experiments are contained in Figures 2 through 14. Shown in the figures are the prices of contracts in the order in which the contracts were executed. The vertical axis is price measured in experimental francs per unit and the horizontal axis is time measured in seconds. The vertical lines designate the end and beginning of periods during the experiment. The average of the competitive equilibrium prices are shown as the horizontal lines. The range of the equilibria is five francs on either side of

such a line. In experiments in which a price ceiling exists the ceiling is represented by a dotted line (the uppermost horizontal line).

Several prominent features are evident from just a brief study of the graphs. First, prices in all experiments converge toward the competitive equilibrium price. When the parameter change occurs in period 11 the prices move away from the old equilibrium toward the new equilibrium. Notice that the variance in prices is greater during the first part of a period and in the early periods.

The first result formalizes what can be learned from a glance at the figures. It is clear that the competitive equilibria capture a prominent feature of market behavior in these subject pools. The collection of principles that are the foundation of this model cannot be rejected as describing behavior in the Russian population. The results demonstrate that there is no need for a completely different set of behavioral principles. The principles of market behavior found in the existing literature do a good job. However, the observation that follows the result demonstrates that market behavior can certainly differ across subject pools in Russia.

RESULT 1. Prices converge to near the upper bound of the competitive equilibria interval was observed across experiments.

SUPPORT. The theoretical competitive equilibrium is [350, 360] for the first set of parameters and after the shift in period 11 to the second set of parameters the competitive equilibrium is [390, 400]. The destination and the direction of the price convergence was evaluated by the application of a modified version of a simple dynamic model, [Noussair, Plott, Riezman, 1995].[7] The model assumes that price (dependent variable) may start from a different origin for each experiment, but as the number of periods becomes large the limit of convergence is assumed to be to a common asymptote. Formally the model is as follows:

$$P_{it}=B_{11}\, D_1(1/t)+ \ldots + B_{1k}D_k+B_2((t-1)/t)+u_{it}$$

where i is the index of the experiment, D_j are dummy variables that take value 1 if i=j and value 0 otherwise, t is measured in terms of experimental period number, K is number of experiments, P_{it} is the average price in period t of the experiment i, u is a random variable, distributed normally with 0 mean. B_{1j} measures origin of the price convergence process and B_2 is its asymptote if the number of periods is infinitely large. The interim (when the number of periods is finite) estimate of the asymptote of convergence in the experiment j is computed as $P^{\wedge} = \mathbf{B}_{jT}(1/T)+\mathbf{B}_2((T-1)/T)$, where the bold letters are parameter estimates, T is the total number of periods in the experiment. Notice that when T becomes sufficiently large all asymptote estimates converge to a common value B_2 and the computed estimate becomes $P^{\wedge} = \mathbf{B}_2$.

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[7] Charles N. Noussair, Charles R. Plott and Raymond G. Riezman, " An Experimental Investigation of the Patterns of International Trade, *The American Economic Review* 85, no. 3 (1995):462-491.

Data in Tables 3 and 4 show ordinary least squares estimations of the model, P^, before and after the shift in the parameters (11th period) respectively. Parameters of main interest, the computed asymptotes, are presented in the fourth columns of the tables. Before the shift occurred (Table 3), in all but one experiment the estimated asymptotes of the convergence have values between 357 and 361. Remember that the set of competitive equilibrium prices is the interval [350-360]. Thus the convergence was consistently at the upper bound of the CE set. A similar picture can be observed after the shift has occurred (Table 4). In all experiment the asymptotes were estimated to be between 399 and 401, while the CE interval is [390-400]. Therefore, convergence to a new competitive equilibrium has occurred after the shift, and the asymptotes of such convergence were at the upper bound of the CE set as well.

Observation 1. Behavioral differences exist among the different Russian subject pools before the shift in parameters occurred in the 11th period. Support for this phenomena is weak at best after the shift.

SUPPORT. For each experiment the variances of the transaction prices were computed for the periods 1 through 10, and for the periods 11 through 19 separately. The relevant data are in Table 5. If only the data that appear in the third column of the table are taken into account (periods 1 through 10) then the experiments can be ordered according to this variance measure as follows: Moscow Physical Technical Institute (10, 25); mixed subjects (11); Moscow State University (02, 05, 06, 03, 13); teenagers (28); Russian Open University (27, 14, 30, 26). That is, the two Phys. Tech. markets have the lowest variance. The mixed subjects have the next lowest, etc. Experiment 26 at the Russian Open University has the highest variance. Notice that no overlap exists among these groups in the sense that each subject pool clustered according to this measure. However this clean picture does not hold when the later periods of the experiments are taken into account. As data in the last column of Table 5 show Phys. Tech. subjects have higher (compared to the first 10 periods) variances (4 and 7 before the shift, 9 and 11 after the shift) while the ROU subjects have lower or the same variances (23,25, 17 and 24 before the shift, and 10, 12, 17 and 13 after the shift). The overall picture is that in the first 10 periods there is a clear behavioral difference according to the price variances in the subject pools but in the last 10 periods there is no clear behavioral difference when measured by price variance.

The second result addresses the question about the influence of rent asymmetries. The reported result as found in the literature is that when parameters are such that the competitive equilibrium rents are asymmetric, favoring the buyers, prices start high about the equilibrium and converge into the equilibrium from above. The result states that the markets in Russia behave differently than the markets that have been studied in the west.

RESULT 2. No pronounced tendency exists for these markets to converge from above. Thus the data have no strong support for the asymmetric rent hypothesis. However, there is some weak support.

SUPPORT. The numbers in Table 6 are the average transaction prices per period, per experiment. In only 49 of the 130 periods that constituted the first ten periods of experiments were average prices above the highest competitive equilibrium price of 360 and in only 33 of 116 periods that constituted the last set of periods of experiment were average prices above the highest competitive equilibrium price of 400. Also as the econometric model discussed above suggests, in only 5 of the 13 experiments the direction of price convergence was from above. This can be seen by comparing the first (estimate of origin) and the last (estimate of asymptote) columns of the Table 3 . In only five cases (experiments 10,14, 26, 27, 30) is the origin higher than the asymptote.

The weak support lies in the fact that the B_2 estimate is above the competitive equilibrium prices range. Thus, while these markets do not start far above the competitive equilibrium and converge downward, the prices are nevertheless on average high relative to the competitive equilibrium. That is, prices are converging on average, to a point above the competitive equilibrium range.

The third result explores the impact of the price ceiling. Price ceilings above the competitive equilibrium are reported to cause the price adjustments to converge from below. That feature was not observed in the Russian markets. The next result makes that clear.

RESULT 3. No dampening effect of the nonbinding price ceiling can be detected in the data.

SUPPORT. Price ceilings were imposed in four experiments: 06, 10, 11 and 27. Consider only the first ten periods of an experiment before a shift, and compare the estimates of the origin and the asymptote (Table 3). The estimates suggest that the convergence was from above in two of these four experiments (10 and 27), and the convergence was from below in the other two experiments (06 and 11). Also, of the forty periods (periods 1 through 10 in these four experiments) only seven had prices below the lowest competitive equilibrium price (Table 6). Therefore, prices cannot be said to be below equilibrium or to approach the equilibrium from below in these experiments.

Result 1 suggests that the transaction cost did not prevent convergence to the competitive equilibrium. That fact is summarized by the next result. The result also documents that the transaction cost does have expected effects.

RESULT 4. The existence of a transactions cost:
(i). did not prevent the convergence to the competitive equilibrium;
(ii) decreased the number of bids and asks; and,
(iii) increased the number of multiple unit bids and asks.

SUPPORT. First consider part (i). The taxes on bids and asks were imposed in experiments 13, 14, 25, 28 and 30. Estimates of origins and asymptotes in the Tables 3

and 4 can be used to assess the degree to which these experiments were converging to the competitive equilibria. Of the five experiments (before and after each shift) only one asymptote estimate (experiment 14 before the shift) has a hint of being significantly different from the competitive equilibria (363), compared to the upper bound of the price range at 360, and the magnitudes of the deviation is small. In other cases all of the asymptotes estimates are near the CE level as can be seen from the numbers in the last columns of the Tables 3 and 4 . Clearly there is a general tendency for these markets to converge.

Consider next part (ii). As can be seen from the second and the third columns of Table 7 numbers of Bids/Asks made in the experiments that involved price ceilings (shadowed rows) are consistently lower (with one exception - experiment 10) than the numbers of Bids/Asks made in the other experiments.

Finally consider part (iii). The average of the shadowed numbers in the last column of Table 7 (numbers of multiple units bids and asks when the price ceiling is imposed) is 194, while the same average for the other experiments 146. Therefore, it is concluded that price ceiling resulted in an increase in the numbers of multiple units bids and asks.

The next result concerning the importance of bids and asks is rather surprising. One of the most persistent properties of market convergence behavior has been the relationship between price changes, the number of bids and the number of asks. In particular, for markets in the west, the number of bids in a period minus the number of asks is a predictor of price movements in the following period. That is not true of the Russian markets.

RESULT 5. The bid/ask adjustment equation does not predict price movements in these markets.

SUPPORT. The equation $P_t - P_{t-1} = a + b$ [(number of bids in t-1) - (number of asks in t-1)] was estimated for each experiment. P_t = average price in period t. The first period and the period immediately following the shift were not used in the estimation. The estimated coefficients are presented in Table 8. Notice that the coefficient b (the third column of the Table) has a positive sign as is the case in all but two experiments (28 and 30). However, the significance level (the t-statistic as shown in the last column of the Table) was low (less than 2) in all cases but two of the thirteen experiments (05 and 11). Therefore, we conclude that the bid/ask adjustment equation does not predict price movements in these markets.

The next result is known to the literature. It reflects the advantage of the first mover that follows from game theoretic intuition.

RESULT 6. The price of contracts in which an ask to sell was accepted by a buyer tend to be higher than the contract price in which a bid to buy was accepted by a seller.

SUPPORT. The average price of the contracts in which an ask was taken by a buyer was computed for every period of every experiment as was the average price of the contracts in which as bid was taken by a seller. The numbers in Table 9 are differences between the former and the latter. Empty cells mean that these were periods with either no asks taken or were periods in which no bids were taken. In only 5 of the 246 periods was the difference less than zero. Therefore asks taken are at higher prices than are bids taken.

5. THE *HVATAT* PROPERTY

The above section makes it clear that these experiments with Russian subjects have some properties that are different from markets studied in the west. Support for the asymmetric rent hypothesis is weak at best. The number of bids minus the number of asks does not predict price changes well; and nonbinding price ceilings do not have the expected effect. In addition, the behavior of the markets differs across subject pools thereby providing support for a presumption that the key to the differences resides in the properties of individuals as opposed to the experimental environment. A natural question to pose is whether the sociological background and life experiences could account for what is observed.

In Russian, "*hvatat*" means "to grab." The basic idea of *Hvatat* is that some buyers and sellers whom we will refer to as "rabbits," bring their worldly experiences to the laboratory with them and are anxious to trade. Coming from a world of shortages their instincts are to "grab," to be quick to acquire anything of value while the opportunity exists. Buyers who are rabbits have a propensity to accept whatever ask is tendered if it is profitable for them and sellers who are rabbits have a tendency to accept whatever bid is tendered as long as it is profitable. The propensity to act passively and accept offers is accompanied by a tendency to rush wherever they suspect that something of value might exist and "grab it" quickly before someone else does. This is all tempered by a tendency towards myopia in the sense that the subjects do not gather or process relevant information that might lead them to alternative strategies involving waiting and negotiating. Of course, such anxiousness and myopia are not consistent with the spirit of game theory which would have the same agents seeking higher profits by developing a more thoughtful search strategy.

Thus in a sense, the principles with which we begin are based on a sort of irrationality that is fostered by experiences, expectations and instincts that were developed outside the laboratory. However, these life experiences do not have the same impact on all people. Behavior differs within this subject pool.

A second type of subject, that we will call wolf, evolves in response to the existence of rabbit behaviors. Wolves exhibit a type of hunting/predator behavior that is forward looking and appears to be in the spirit of a best response to the rabbits. They set traps and move to be in a position to capitalize on the habits of the rabbits. Thus, as hunters the wolves are "trappers" who anticipate the movements of the prey and set a trap reflecting

that anticipation. Rabbits, by contrast exhibit the opportunistic propensities of a stalker who surveys the field and when food is observed rushes quickly to gather or capture it. The trapper initiates the contracts by making the offers (setting the traps) and the stalker terminates the contracts by accepting the offers (rushing to take advantage of offers that have been made).

The analysis will proceed with an attempt to find support for statements that describe a statistical relationship between a subject's behavior and the subject's relative success. The general conjecture advanced in this section is that the existence of these two types of agents in the markets, rabbits and wolves, effects the market dynamics in such a way that some of the conventional properties of markets do not hold (as shown in the previous section). Of course, these ideas are not sufficiently formal to rigorously test and the experiments were not designed to test for such phenomena anyway. Thus, this section develops conjectures and organizes such support that exists.

The first conjecture relates the intuitive concepts of rabbits and wolves to particular properties of the experimental markets. These properties are thus used to identify wolves and rabbits as properties of individual subjects.

CONJECTURE 1. The presence of the two different types of agents (wolves and rabbits) in the markets resulted in the following properties of the data.
(i). The more "active subjects" in terms of making bids or asks, tend to extract more profits. Subjects with a tendency to be trappers are more profitable.
(ii). Subjects specialize as trappers or stalkers. They tend to either always initiate the transaction by tendering bids or asks (trapping) or always terminate the transaction by accepting bids or accepting asks (stalking).
(iii). Most of the transactions are made early in a period (usually the first minute).
(iv). Subjects who terminate many transactions during the first minute of a period (the quick stalkers), tend to have lower profit than those who tend to initiate transactions during the same time interval (the quick trappers). This phenomena does not hold for the other time intervals and is thus unrelated to the fact that asks taken tend to be at prices higher than bids taken.

SUPPORT. There are four parts of the conjecture that need support. Part (i) is supported by an OLS estimate of the following equation:

$$Y_{ij} = a + b\, X_{ij} + \varepsilon$$

where:

Y_{ij} - is the average relative profit of subject i in experiment j.
Formally $Y_{ij}=[Profit_{ij}/(\sum_{k\in I} Profit_{kj})]500$, where I is a set of all 5 buyers (0, 1, 2 3, 4) if subject i is a buyer or I is the set of all 5 sellers (5,6,7,8,9) if subject i is a seller. $Profit_{ij}$ is the profit of subject i in experiment j.

X_{ij} - is the average relative percentage of Bids/Asks of subject i in experiment j. Formally $X_{ij}=[BA\#_{ij}/(\sum_{k\in I}BA\#_{kj})]500$, where *I* is a set of all 5 buyers (0, 1, 2 3, 4) if subject i is a buyer or *I* is the set of all 5 sellers (5,6,7,8,9) if subject i is a seller. $BA\#_{ij}$ is the number of Bids/Asks that subject i made in experiment j.

OLS estimates of the above equation are in Table 10. Notice that the estimate of b (.0562) is positive and significantly different from zero (t-statistic is 4.5). This suggests that those subjects who make more bids/asks (act more actively) than other members of their trading group (buyers for a buyer and sellers for a seller) tend to have higher profit relatively to the other members of their trading group while less active trader tend to have lesser relative profit.

Part (ii) holds that subjects specialize. In the limit this means that if a subject made N transactions during a period then he either terminated all of them or initiated all of them. Table 11 contains the frequencies which show how many different patterns of such behavior exist in a particular experiment. Consider experiment 02 in which 10 subjects participated for 20 periods, giving a total of 200 observations. Now, the upper left frequency in Table 11 is 53 which means that in 53 of the 200 observations in experiment 02, the subject of the observation terminated 0% of his or her transactions in the period. This means that in experiment 02 there were 53 occurrences when a subject would initiate all of his transactions (would terminate 0%) in a particular period. The lower left corner of Table 11 corresponds to experiment 02's 100% pattern and contains the number 56. This means that in that experiment there were 56 occurrences when a subject would terminate 100% of his transactions in a period. Notice that the numbers in the first and in the last row of the Table exceed numbers in the other rows in all cases except one (experiment 03). This means that 0% and 100% patterns dominated experiments. Thus, subjects specialize.

Part (iii) captures the impact of early transactions. Table 12 contains the numbers of transactions made in the first 30 seconds of a period. For example, there were 93 transactions made in the first 30 second of experiment 03 and there were 11 transactions made in the 30 second interval of 211-240. The table demonstrates that the number of transactions completed in the first minute (the first two 30-second segments) of a period exceed the number of transactions made during any other one minute time interval of that period. Exceptions are experiments 05 and 25. Notice that in experiment 25, which involved Phys. Tech. subjects, only 1 transaction was made during the first 30 seconds of all experiments combined while in two of the four experiments that involved subjects from the Russian Open University (14 and 30) about 50% or more of all transactions were made during the first minute of a period.

Part (iv) stands for the fact that those who tend to grab (*Hvatat*) early in a period usually end up with lower profits. This part is supported by an OLS estimate of the following equations separately for different time intervals:

$$Y_{ij} = a + b\, Z_{ij}^{K} + \varepsilon,$$

where:

K - denotes a particular time interval within a period as follows: K=1 - first 30 seconds K=2 - second thirty seconds, K=3 - second minute, K=4 - third and fourth minute, K=5 - last minute.

Y_{ij} - is the average relative profit of subject i in experiment j.
Formally $Y_{ij}=[Profit_{ij}/(\sum_{k\in I}Profit_{kj})]500$, where *I* is a set of all 5 buyers (0, 1, 2 3, 4) if subject i is a buyer or *I* is the set of all 5 sellers (5,6,7,8,9) if subject i is a seller. $Profit_{ij}$ is the profit of subject i in experiment j.

Z_{ij}^{K}- is the average relative percentage of transactions terminated by subject i in experiment j during time interval K.
Formally $Z_{ij}=[T\#_{ij}/(\sum_{k\in I}T\#_{kj})]500$, where *I* is a set of all 5 buyers (0, 1, 2 3, 4) if subject i is a buyer or *I* is the set of all 5 sellers (5,6,7,8,9) if subject i is a seller. $T\#_{ij}$ is the number of transaction that subject i terminated in experiment j.

OLS estimates of the above equation for five different time intervals are in Table 13 which presents results of five regressions. Notice that the estimate of b is negative and significantly different from zero in the first two regressions which cover the first 60 seconds of a period. This can be seen from the first two regressions in the table: coefficients b are -.24 and -.27, t-statistics are -4.43 and -2.28. None of the other three regressions (the last three regressions in the table) which deal with the other four minutes of a period produce estimates of b significantly different from zero; t-statistics for b are 1.67, -.30 and .78. Thus it is concluded that early "stalker's" activity leads to relatively lower profits and thus points in the direction of a possible rabbit, while this phenomena does not hold for later "stalker's" activity.

The above conjectures establish statistical properties of the data. Whether or not the property of *Hvatat* can be associated with particular individuals is a different story. The next conjecture is that wolves and rabbits can be associated with the behaviors of particular individuals in experiments. It is not just a statistical property of the population. At this time there is no foundation for a conjecture that all individuals can be fit into one of these classes but there is evidence to support the conjecture of the presence of the types.

CONJECTURE 2: Rabbits and wolves can be identified. At least one rabbit and one wolf can be identified in 11 of the 13 experiments (The exceptions are experiments 02 and 25).

SUPPORT. First the presence of rabbits will be demonstrated. As established above, a good indicator of a rabbit is an early "stalker" who tends to have lower than average net profit. Therefore, in search for rabbits we shall compare two sets of data: average relative profits (as defined in the support of Conjecture 1) per subject, per experiment and numbers of early transactions terminated by a subject in an experiment. The former is in the upper part of Table 14, and the latter is in the lower part of Table 14. As an example of how to read the table consider experiment 02 in which subject 0 had profit equal to 99% (upper left corner of the upper part of Table) of the average profit among his fellow buyers (subjects 0,1,2,3 and 4) in that experiment. The upper left corner of the bottom part of the Table shows that this person terminated a total of 15 transactions within the first minute of periods in that experiment.

In all but three experiments subjects who had highest (among participants of the same experiment) numbers of transactions terminated in the first minute have lowest (or among lowest) relative profits. These suspected rabbits are shadowed in the Table. For example, in experiment 30 subject 2, a buyer, terminated 58 transactions early and his relative profit was 87% of average among buyers in that experiment. According to the "model" this type of behavior can be attributed to rabbits. Notice that for each experiment only one or two such suspects are identified. If in addition to the outliners (shadowed), subjects who simply terminated a lot of transactions early are also taken into account, then there is no consistency between these numbers and profits. For example, subjects 0 and 1 in experiment 6 terminated 25 and 27 early transactions respectively. These are rather high numbers since 5 of 10 of participants of that experiments terminated less than 10 such transactions. On the other hand these two subjects' profits are both 101% of the average. Therefore, as a group they do not fit the profile of rabbits as they are being characterized here. The measure of rabbits is crude and in order to identify rabbits beyond those that exist in the extremes, a more refined measure will be needed. Thus, although there is a possibility that there were more rabbits than we identified in each experiment, they cannot be identified with this particular criteria of individual behavior.

As a second step in the support of the conjecture, the existence of wolves must be established. Wolves can primarily be identified by their relationship with rabbits. If there were no rabbits, then wolves may be hard to spot. On the other hand, if rabbits exist among the buyers then one must study to determine if a wolf might have become distinguished from among the sellers. If rabbits are on both sides of the market then it might be possible to identify wolves on both sides of the market as well. The concept of "wolf" is symmetric with the concept of "rabbit". Therefore we should look for early successful trappers. Refer again to Table 14. In experiment 03 (the second column) a suspected rabbit is subject 0 (a buyer). Therefore we look for wolves among the sellers. Subject 9 (a seller) has the lowest early termination rate among the sellers. He terminated just one early transaction during the experiment (bottom part of the table). Consistently with the concept of wolf he is one of the most successful subjects among the sellers; his average relative profit is 108% (upper part of the table). Repeating this procedure for the other experiments (respectively, experiments 05, 06, 10, 11, 13, 14, 25, 26, 27, 28 and 30) subjects 3, 3, 8, 2, 3, 5, 6, 5, 1, 6 and 6 can respectively be identified as wolves. Notice

that in 8 of the 10 cases the identified wolves are the most successful ones and have the lowest termination rate of early transactions within their group of buyers or sellers. The two exceptions are experiments 13 and 14.

If individuals can be successfully classified as rabbits then one immediately asks about whether the property is temporary or seems to remain under a variety of conditions. If the property is only temporary then one might question the value of the classification. The next conjecture characterizes what appears to be in the data.

CONJECTURE 3 (stability) . The classification of individuals remains the same when estimated from the data set before shift and the data set after shift or in the pooled data set.

SUPPORT. Recall that all experiments involved two different sets of parameters. Subjects who are classified as extreme rabbits or wolves hold the same tags if the data are separated into two sets- before the parameter shift and after the parameter shift. The columns in Table 15 are the time series of numbers of early transactions that were terminated by (classified) rabbits. It shows that there are no tendencies for these numbers to decrease by the end of an experiment. For example subject 6 in experiment 5 (second column of the table) terminated 14 early transactions before the shift occurs (first ten rows of the table) and 17 early transactions after the shift (last nine rows of the table). This pattern holds for other subjects as well, with the exception of subject 5 in experiment 13 (seventh column of the table), who terminated 18 early transactions before the shift and terminated only 10 early transactions after the shift.

The numbers in the table are closely related to the profitability of a subject in an experiment. Therefore, if the numbers do not decrease with time, the rabbit classification remains robust against data separations. Subjects who are classified as wolves terminated the least numbers of early transactions in the whole experiment (usually no more than 5). Therefore, if periods before and after the shift are considered separately, then the classification remains the same because the numbers can only decrease from being already low.

The next conjecture attempts to associate the *Hvatat* property and associated rabbits and wolves, with the overall market behavior.

CONJECTURE 4. The presence of wolves and rabbits in the experiments caused the absence of the conventional features of the markets. In particular the existence of rabbits and wolves cause (i) high price variance, (ii) the absence of a strong rent asymmetry effect and (iii) the absence of the pushing property of price ceilings.

SUPPORT. This conjecture is based on an idea about the mechanism through which the presence of rabbits and wolves could operate. The idea is that the existence of rabbits affects the variance of prices which in turn has an impact on the direction of convergence and accounts for the lack of a strong rent asymmetry effect and the lack of a strong price

control effect. The idea in support of part (i) starts with the presumption that there are rabbits and wolves on both sides of the market. The wolf buyers will tender low bids that are immediately accepted by rabbit sellers and the wolf sellers will tender high asks that are immediately accepted by rabbit buyers. The result is a high price variance that continues until the trading capacity of rabbits is exhausted. This high variance leads to little period to period adjustment. Part (ii) rests on the observation that the lack of period to period adjustment is a different dynamic than typically exists. Ordinarily prices adjust from one side or the other. If prices start high the dynamic is to approach from above and if they start low the dynamic is to come in from below. However, in the presence of rabbits and wolves high prices may not be followed by high prices as the wolves on the other side of the market set their traps. Thus, if prices start high they are not followed by high prices and thus there is no consistent convergence from above. Thus, to understand part (iii), if there is no coordination of strategies in general in the sense of a convergence process, there cannot be a coordination of strategies caused by the price ceiling. Thus the price ceiling did not have the dynamic effect that has been previously observed.

Data that demonstrate the possible impact of extreme rabbits on the dynamics of the price adjustment process help with a possible characterization of part (iii) of the conjecture. Given the crude tools only extreme behaviors are identified but in 11 of the thirteen experiments (all but experiments 02 and 25) rabbits could be identified. Rabbit buyers were identified in experiments 03,06,10,13,14,26,27 and 30. Rabbit sellers were identified in experiments 05,11,13 and 28. Notice that in ten experiments (all but one, experiment 13) the identified rabbits were only on one side of the market. If extreme rabbits have an influence on price the one would expect the former experiments (with extreme rabbit buyers) to converge from above and the latter (with extreme rabbit sellers) to converge from below. The estimated origin B_{ij} in Table 3 indicates the direction of convergence (by comparison with the asymptote). Of the ten experiments considered, five converged from above (experiments 10,14,26,27 and 30) and five converged from below (experiments 03, 05, 06,11 and 28). Thus in 8 of the 10 experiments under consideration, the direction of price convergence was from the side of the identified extreme rabbit.

The thesis above is that the *Hvatat* phenomena is responsible for the special market behaviors that are observed. That thesis naturally suggests additional questions about why the phenomena exists. Were the Russian subjects exhibiting learned behavior or is the *Hvatat* property a more general feature of behavior when people have a degree of confusion or lack of understanding? The question that follows is stated in a manner to focus on the issue.

THE QUESTION: PREDISPOSITION or CONFUSION?
(i) THE PREDISPOSITION HYPOTHESIS: The *Hvatat* property reflects a predisposition to the use of certain types of strategies and also a predisposition to be insensitive to information that would cause a change in those strategies.
(ii) THE CONFUSION HYPOTHESIS: The *Hvatat* property reflects confusion on the part of some people. When they are confused they act with a certain myopia that leads to

quick actions when any profits are seen and a myopia that prevents the use of other strategies.

On one hand, the Russian subjects might simply be using strategies that they have used in the economy with which they have experience. A strategy of quick "grabbing" is useful in their daily lives. Clearly such a suspicion lead us to investigate the possibility of a *Hvatat* property as part of subject behavior in the first place. The idea that shortages would give people training in that mode of behavior is very consistent with experimental evidence. For example, experiments with artificial limitations on market volume exhibit a tendency for subjects to grab whatever exists (Plott, 1983)[8]. That is, when the equilibrium volume is x but market activity is limited to x-y<x individuals clamor to be among the first x-y traders. Price variance is high and there is no real evidence of convergence to the unconstrained equilibrium price . The most profitable individuals are those that are quickest to grab whatever might exist in the market. There is no negotiation since the shortage gives each trader a "take it or leave it" choice. If the offer is not taken immediately when it presents itself then it is lost completely. Experience with shortages could certainly teach people to "grab".

On the other hand the *Hvatat* phenomena cannot be observed in all experiments. The phenomena is "spotty" in the sense that it is simply not observed in the Phys. Tech. experiments, such as experiment 25. No subject is quick to grab whatever profitable deals might exist in the market and the price variance is very small. Therefore it is impossible to claim there will be rabbits in any Russian subject pool just because it is a Russian subject pool. For a number of reasons Phys. Tech. subjects are assumed to be the quickest to understand the instructions and how to participate in the markets. This lends support to the idea that some of the subjects in the non Phys. Tech. subjects were simply confused by a new type of activity and were slow to catch on. Thus, confusion could be responsible for the existence of the phenomena.

However, the phenomena has a degree of persistence as was shown in Conjecture 3. If it is confusion then one would expect it to go away with experience. It is with this argument that one can see the two hypotheses joined to produce an unusual type of *Hvatat equilibrium*. While there is a reduction of variance and convergence over time, it was slow. The high variance made any tendency for convergence hard to detect and many Russians were not predisposed to look for or expect any type of equilibration. Those with the greater confusion were less likely to absorb the equilibration tendencies that existed. Thus, those with tendencies to be rabbits retained that proclivity and did not learn from the signals that existed in the market. Of course their presence in the market provided the self fulfilling expectations by maintaining high variance in the markets.

Thus, both ideas can find support in the sense that a predisposition existed to grab that was exacerbated by confusion in the groups that had less learning capacity. The subjects

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[8]C. R. Plott, "Externalities and Corrective Policies in Experimental Markets," *Economic Journal* 93 (March 1983):106-127.

did not expect to see equilibration and thus very little learning was reflected in their behavior. On the other hand the subjects from Phys. Tech. captured the logic of the situation and behaved in a very "western" manner. The Phys. Tech. subjects detected the equilibration and their awareness reinforced the tendency whereas subjects from other subject pools did not detect the signals that existed and thus did not alter their behavior accordingly.

6. CONCLUSION

The law of supply and demand works well in Moscow. A degree of anxiousness seems to exist in some subjects in the sense that they are too quick to act at first. It is as though they are impulsive or follow a rule of thumb that tells them to accept anything that is to their benefit without waiting and studying the market conditions. Nevertheless, the tendency is not so pronounced that it prevents the operation of the pervasive market forces of convergence.

Phenomena that have been observed but not explained in experiments in the west are not observed in these Russian experiments. In that sense the data reported here are very different. Prices do not converge from the direction of rent asymmetry. Nonbinding price controls do not have the effect that has been observed in the west. The bid/ask equation that captures price movements so well in the west does not work in these data.

The experiments produced two results that have only recently been reported in the literature. First, the existence of a transactions cost (that does not alter the gains from marginal trades) does not alter the equilibrating tendency to the competitive equilibrium. This is a particularly interesting finding that forms a beginning for investigations of transactions costs that are independent from the notions of information and search. Secondly the prices of asks that are taken tend to be above the prices of bids that are taken. Hopefully this property will be investigated in the data that exists for experiments that have been conducted in the west. It may provide another tool for the analysis of the dynamics of the price discovery process

We seem to have discovered an interesting property of human behavior. The concept of *Hvatat* led us to look carefully at the subjects. Our predisposition was to think that social background was responsible for creating a subject pool willing to myopically grab anything in a market that they felt was advantageous and to do so without search or "negotiation." We characterized such impulsive behavior as "rabbit-like" and proceeded to look closely for rabbits. We reasoned that the social influences and resulting rabbits would account for the differences in market behavior in the east as compared to the west. Interestingly enough, close examination revealed that there does not seem to have been many rabbits. In addition, wolves, which were a different type of subject, emerged from the subject pool in response to the rabbits that did exist. This fact, and the fact that we saw dramatic differences among Russian subject pools, led us to suspect that the rabbit and wolf behaviors are typical of people in general. Our conjecture

is *Hvatat*, the rabbit behavior, is characteristic of confusion, conservatism that reflects confusion, or differential learning as opposed to some sort of social preconditioning. Our observations are such that we wonder if this type of behavior might be observed in the west as well as in Russia. It might have been more pronounced in Russia because the abstract setting of the experiment was less familiar. Thus, perhaps confusion and the behavior it produces was more pronounced in Russia; and it was possibly only our mistaken belief about the impact of the culture that led us to look.

Table 1: Experimental Conditions

Experiment Number	Location Subjects	Price Ceil. Exits (period)	Bid/Ask tax (period)	Param. change (period)
921102; No.02	Moscow University year 4-5	none	none	(0-10) (11-end) sys.bk.(15)
921103; No.03	Moscow Univ. year 3	none	none	(0-10) (11-end)
921105; No.05	Moscow Univ. year 1	none	none	(0-10) (11-end)
921106; No.06	Moscow University year 4-5	380 (0-8) 420 (9-end)	none	(0-10) (11-end)
921110; No.10	Moscw.Phys. Tech.Instit.& M.S.U.mixed	380 (0-8) 420 (9-end)	none	(0-10) (11-end) sys.bk. (13)
921111; No.11	Mixed	390 (0-8) 420 (9-end)	none	(0-10) (11-end)
921113; No.13	Moscow.Univ. year 4-5	none	3 all periods	(0-10) (11-end)
921114; No.14	Russian Open Univ.	none	3 all periods	(0-10) (11-end)
921125; No.25	Moscow Phys.Tech. Inst.	none	4 all periods	(0-10) (11-end)
921126; No.26	Russian Open Univ.	none	none	(0-10) (11-end)
921127; No.27	Russian Open Univ. Businessmen	390 (0-8) 420 (9-end)	none	(0-10) (11-end) sys.bk.(10)
921128; No.28	Teenagers	none	2 all periods	(0-10) (11-end) sys.bk. (1)
921130; No.29	Russian Open Univ. Businessmen	none	4 all periods	(0-10) (11-end)

Table 2. Induced Values and Costs.

PERIODS 0-10				PERIODS 11-END			
RedemptIon Value	Buyer I.D.	Unit Cost	Seller I.D.	Redemption Value	Buyer I.D.	Unit Cost	Seller I.D.
510	0	275	5	550	4	315	9
510	1	275	6	550	0	315	5
510	2	275	7	550	1	315	6
500	3	280	8	540	2	320	7
490	4	285	9	530	3	325	8
480	4	290	9	520	3	330	8
470	3	295	8	510	2	335	7
460	2	300	7	500	1	340	6
450	1	305	6	490	0	345	5
440	0	310	5	480	4	350	9
430	0	315	5	470	4	355	9
420	1	320	6	460	0	360	5
410	2	325	7	450	1	365	6
400	3	330	8	440	2	370	7
390	4	335	9	430	3	375	8
380	4	340	9	420	3	380	8
370	3	345	8	410	2	385	7
360	2	350	7	400	1	390	6
360	1	350	6	400	0	390	5
360	0	350	5	400	4	390	9
350	0	360	5	390	4	400	9
340	1	370	6	380	0	410	5
330	2	380	7	370	1	420	6
320	3	390	8	360	2	430	7
310	4	400	9	350	3	440	8
300	4	410	9	340	3	450	8
290	3	420	8	330	2	460	7
280	2	430	7	320	1	470	6
270	1	440	6	310	0	480	5
260	0	450	5	300	4	490	9

Table 3 .

Ordinary least square estimation of the convergence process before the shift in parameters (periods 1-10).

Experiment	Estimated Coefficients		Computed Asymptotes	Competitive Equilibrium
	B_{1j}	B_2	P^	P
02	335.5	361.1	358.5	[350-360]
03	350.7	361.1	360.0	[350-360]
05	356.7	361.1	361.1	[350-360]
06	323.5	361.1	357.3	[350-360]
10	361.3	361.1	361.1	[350-360]
11	340.8	361.1	359.0	[350-360]
13	332.6	361.1	358.3	[350-360]
14	385.0	361.1	363.5	[350-360]
25	355.7	361.1	360.6	[350-360]
26	366.5	361.1	361.7	[350-360]
27	364.9	361.1	361.5	[350-360]
28	346.3	361.1	359.6	[350-360]
30	361.5	361.1	361.1	[350-360]

R-squared	0.45879
Corrected R-squared	0.398
Sum of Squared Residuals	6838.7
Standard Error of the Regression	7.678
Durbin-Watson Statistic	1.265
Mean of Dependent Variable	358.6

Table 4 .

Ordinary least square estimation of the convergence process after the shift in parameters (periods 11-19).

Experiment	Estimated Coefficients		Computed Asymptotes	Competitive Equilibrium
	B_{1j}	B_2	P^	P
02	361.0	405.6	401.1	[390-400]
03	354.4	405.6	400.4	[390-400]
05	345.5	405.6	399.6	[390-400]
06	364.0	405.6	401.4	[390-400]
10	361.7	405.6	401.1	[390-400]
11	353.5	405.6	400.4	[390-400]
13	359.4	405.6	401.0	[390-400]
14	368.2	405.6	401.9	[390-400]
25	348.2	405.6	399.9	[390-400]
26	377.3	405.6	402.7	[390-400]
27	382.4	405.6	403.3	[390-400]
28	350.9	405.6	400.1	[390-400]
30	359.1	405.6	401.0	[390-400]

R-squared	0.86570
Corrected R-squared	0.85064
Sum of Squared Residuals	3185.3
Standard Error of the Regression	5.240
Durbin-Watson Statistic	0.892
Mean of Dependent Variable	392.4

Table 5 .

Standard Deviations of Transaction Prices

Experiment		Standard Deviations of Transaction Prices	
Number	Subject Type	Periods 1...10	Periods 11 ... 19
02	MSU	14.452	6.587
03	MSU	15.294	14.530
05	MSU	12.159	12.508
06	MSU	14.741	8.456
10	PhysTech	4.894	9.053
11	Mixed	12.165	9.583
13	MSU	17.557	11.646
14	ROU	23.247	10.817
25	PhysTech	7.415	11.491
26	ROU	25.256	12.494
27	ROU	17.616	17.305
28	Teenagers	18.985	13.402
30	ROU	24.771	13.372

Table 6 .

Average Transaction Prices (per period, per experiment).

	Experiment #												
	02	03	05	06	10	11	13	14	25	26	27	28	30
Period	Average Transaction Prices (per period, per experiment)												
1	340	351	364	331	357	341	344	360	350	370	354	352	364
2	341	355	364	338	365	348	335	392	364	350	361	358	354
3	346	352	356	343	365	353	354	388	363	363	369	356	360
4	346	362	357	342	363	359	344	376	365	377	363	353	359
5	357	365	344	345	362	358	349	371	362	361	364	352	356
6	356	362	346	350	361	358	349	375	359	346	369	348	365
7	360	359	354	352	360	358	348	372	358	365	367	344	364
8	363	354	354	352	359	356	354	372	359	366	367	346	363
9	364	358	355	361	360	357	354	368	356	361	385	353	370
10	365	357	353	365	359	361	358	365	356	365	382	354	358
Shift in Parameters Occurs													
11	385	372	370	380	379	374	379	388	370	386	396	375	384
12	387	386	379	391	391	383	386	399	376	399	392	382	385
13	389	388	387	397	399	387	393	394	385	418	402	383	393
14	392	393	391	402	403	393	405	398	393	416	402	396	395
15	395	400	397	403	403	394	408	400	395	412	401	399	398
16	394	402	399	399	401	395	408	401	397	412	400	398	400
17	395	404	392	397	401	395	401	401	400	409	401	400	398
18	394	404	393	396		396	395	399	398	407	402	401	403
19	399	402	394	391		397	396	398	399	404	401	405	406
20	398												

Table 7 .

BIDS/ASKS Activity.

Experiment #	Average Numbers of BIDS/ASKS Made by an Individual in a Period	Total Numbers of BIDS/ASKS Made in the Experiment	Total Numbers of Multiple Unit BIDS/ASKS Made in the Experiment
2	18.0	1760	144
3	18.1	1794	166
5	18.8	1875	11
6	16.5	1631	33
10	10.2	991	332
11	17.4	1740	19
13	10.0	979	99
14	13.0	1170	270
25	6.8	682	368
26	17.6	1760	355
27	16.9	1517	115
28	9.6	957	102
30	13.0	1264	134

Experiments with Price Ceiling Imposed.

Table 8 .

OLS Estimates of the Bid/Ask Adjustment Equation

$P_t - P_{t-1} = a + b[(\#\text{bids in t-1}) - (\#\text{asks in t-1})]$

Experiment	Independent Variable	Estimated Coefficient	Standard Error	t-Statistic
02	a	4.69	1.492	3.145
	b	0.20	0.120	1.671
03	a	4.48	3.010	11.489
	b	0.14	0.160	0.905
05	a	-19.02	10.093	-1.884
	b	0.56	0.275	2.039
06	a	2.99	1.487	2.009
	b	0.086	0.179	0.482
10	a	2.97	1.847	1.609
	b	0.15	0.126	1.220
11	a	6.81	2.022	3.370
	b	0.24	0.103	2.340
13	a	1.33	2.759	0.482
	b	0.22	0.195	1.119
14	a	6.03	5.077	1.187
	b	0.32	0.238	1.324
25	a	3.00	1.538	1.950
	b	0.31	0.243	1.262
26	a	5.30	4.102	1.291
	b	0.24	0.262	0.930
27	a	0.08	4.055	0.019
	b	-0.13	0.178	-0.714
28	a	-2.70	5.012	-0.538
	b	0.27	0.251	1.091
30	a	1.98	4.503	0.439
	b	-0.078	0.259	-0.295

Table 9 .

Differences between the average price of a contract in which an ask was taken by a buyer and the average price of a contract in which a bid was accepted by a seller (per period, per experiment).

	Experiment #												
	02	03	05	06	10	11	13	14	25	26	27	28	30
Period#	Differences Between the Average Price of an Ask Taken and the Average Price of a Bid Taken, per period, per experiment												
1	7	52	15	0	11		30		10	11		34	-8
2	16	35	16	12	8	18	25		7	34	40	38	50
3	15	26	21	20	5	18	33	48	9	66		27	42
4	11	18	31	6	4	6	30	43	9	35	54	23	39
5	13	24		13	5	16	28	40	7	32	38	27	40
6	9	8		8	3	15	19	25	1	1		15	39
7	11	13	14	16	2	10	6	17	1	20		28	38
8	8	13	11	5	1	6	11	23	1	13		0	38
9	12	6	3	9	1	13	4	16	4	7	22	10	
10		10	8	11	1	4	7	16	1	12	23	11	9
11	16	26		12	-4	16	12	15	9	21		28	
12	13	14	17	0	-3	9	9	10	6	0		18	12
13	7	14		-1	0	6	7	6	2	17		11	36
14	8	11		6	4	0	7	-1	2	8		8	6
15	4	11		2	3	2	5	3	2	1		1	
16	2	4	0	6	2	6	5	1	0	5	10	2	11
17	0	9		4	0	2	2	5	0	10	2	6	
18	3	8		2		4	6	3	1	6	12	0	24
19	2	4		3		4	1	8	1	5	10	0	
20	1							0	0	0			

Data are rounded to the nearest integer.

If a cell is empty then transactions of only one type (Bid Taken or Ask Taken) occurred during that period.

Table 10.

OLS Estimates of the Average Relative Profit as a Function of the Number of Bids/Asks made by an Individual

$Y_{ij} = a + bX_{ij}$, where:

Y_{ij} - is the average relative profit of subject i in experiment j.
Formally $Y_{ij}=Profit_{ij}/(\sum_{k\in I}Profit_{kj})$, where *I* is a set of all 5 buyers (0,1,2 3, 4) if subject i is a buyer or *I* is the set of all 5 sellers if subject i is a seller. $Profit_{ij}$ is the profit of subject i in experiment j.

X_{ij} - is the average relative number of Bids/Asks of subejct i in experiment j.
Formally $X_{ij}=BA\#_{ij}/(\sum_{k\in I}BA\#_{kj})$, where *I* is a set of all 5 buyers (0, 1, 2 3, 4) if subject i is a buyer or *I* is the set of all 5 sellers if subject i is a seller. $BA\#_{ij}$ is the number of Bids/Asks that subject i made in experiment j.

Coefficient	OLS Estimate	Standard Error	t-Statistic
a	94.37	1.380	68.382
b	5.62e-002	1.251e-002	4.496
Number of Observations	130		
R-squared	0.136		
Corrected R-squared	0.129		
Sum of Squared Residuals	5634.2		
Standard Error of the Regression	6.634		
Durbin-Watson Statistic	2.382		
Mean of Dependent Variable	100		

Table 11.

Frequencies of Different Patterns of Behavior.

Event X% : X=T/(I+T)*100

where: T - number of transactions that a subject terminated in a period
I - number of transactions that a subject initiated in a period

	Experiment #												
	02	03	05	06	10	11	13	14	25	26	27	28	30
Event	Frequencies of Events in Experiments												
0%	53	35	80	45	43	44	40	63	51	46	83	60	66
16.6%	0	1	0	0	0	0	0	1	0	2	0	0	0
20%	2	3	0	0	2	0	0	1	1	1	1	0	1
25%	28	23	6	21	25	24	17	13	16	13	6	13	13
33.3%	3	10	2	10	7	10	22	9	14	13	1	8	12
40%	2	4	0	4	1	5	0	0	0	0	0	0	0
50%	24	30	7	29	17	25	31	8	27	34	5	19	7
60%	1	2	0	3	2	3	2	1	1	3	1	0	1
66.6%	4	13	5	5	6	7	13	10	11	12	1	12	9
75%	24	37	10	25	16	30	30	23	16	19	9	23	10
80%	3	3	3	2	0	1	0	2	1	2	1	1	0
100%	56	29	77	46	51	41	35	59	52	45	82	54	71

Table 12.

Numbers of Transactions (Trade Volume) made during different time intervals.

	Experiment #												
	02	03	05	06	10	11	13	14	25	26	27	28	30
Time interval	Numbers of Transactions												
0-30 sec.	102	93	26	72	88	67	64	145	1	71	91	70	111
31-60 sec.	80	73	36	87	39	61	67	67	18	67	71	63	66
61-90 sec.	64	44	46	50	46	56	57	34	28	44	62	60	49
91-120 sec.	45	35	34	46	27	39	41	29	33	41	40	37	29
121-150 sec.	28	28	35	36	26	40	38	22	39	31	25	34	23
151-180 sec.	23	24	26	24	12	20	17	12	34	23	23	26	20
181-210 sec.	14	18	28	14	14	19	18	12	37	15	15	15	12
211-240 sec.	10	11	28	7	15	23	17	9	32	19	14	12	13
241-270 sec.	17	19	35	13	20	18	16	12	41	16	11	15	17
271-300 sec.	11	19	49	18	29	23	15	9	35	20	16	20	11

Table 13.

OLS Estimates of Average Relative Profits as a Function of the Number of Transactions Terminated by an Individual During Different Time Intervals.

Coefficient	OLS Estimate	Standard Error	t-Statistic	R^2
Regression #1: First 30 Seconds of a Period				
a	102.8	.699	146.6	.12
b	-.24	.055	-4.433	
Regression #2: Second 30 Seconds of a Period				
a	101.6	.823	123.5	.07
b	-.27	.096	-2.889	
Regression #3: Second Minute of a Period				
a	98.7	.96	102.4	.02
b	.15	.089	1.67	
Regression #4 Third and Fourth minutes of a Period				
a	100.2	1.01	99.45	.0007
b	-.02	.09	-.30	
Regression #5 Last minute of a Period				
a	99.5	0.80	123.8	.004
b	0.11	0.13	0.78	

Table 14

Average Relative Profits (as defined in Conjecture 1) and Numbers of Transactions Terminated By the Subject in the First Minute of Each Period, per Period, per Experiment.

	Experiment #												
	02	03	05	06	10	11	13	14	25	26	27	28	30
Subject Number[1]	Average Relative Profit Over All Periods[2]												
0	99	94	95	101	106	101	99	108	101	90	88	101	97
1	99	98	98	101	101	97	101	92	100	107	107	105	105
2	103	101	99	95	97	102	101	106	103	101	111	98	87
3	100	99	105	108	95	99	104	99	93	104	96	94	100
4	96	105	101	93	99	98	92	93	101	96	96	100	107
5	97	85	105	103	99	89	92	109	98	92	107	99	100
6	89	114	94	106	99	93	101	100	103	108	103	109	134
7	106	95	98	93	99	107	99	76	101	105	77	95	88
8	98	96	96	97	101	105	112	107	94	99	112	93	90
9	107	108	104	99	100	104	94	105	102	94	99	101	86
Total (All Periods) Numbers of Transactions By the Subject Terminated in the First Minute													
0	15	37	0	25	21	19	4	23	2	30	56	5	25
1	49	6	5	27	30	12	3	64	1	6	30	0	17
2	50	26	0	9	16	8	6	11	1	11	17	9	58
3	17	13	0	3	54	13	1	48	1	5	23	5	13
4	14	31	0	49	1	22	27	45	2	39	32	2	36
5	14	13	5	1	2	21	27	7	4	8	0	32	3
6	15	5	29	0	1	27	19	0	1	6	0	14	1
7	1	20	16	23	0	0	14	13	3	8	5	28	13
8	2	15	5	13	0	3	17	1	2	13	0	10	11
9	5	1	2	9	3	3	13	0	2	12	0	28	0

Note: A subject numbered i in experiment j had exactly the same parameters as the (different) subject numbered in experiment k.

Note: The shaded cells in the lower panel represent the "most active" subjects in the experiment. Shaded cells in the upper panel correspond to the shaded cells in the lower panel. Thus the table facilitates a comparison of relative activity data and relative profits data.

[1] A subject numbered i in experiment j had exactly the same parameters as did the (different) subject i in experiment j'.

[2] Shaded cells in the lower panel represent the "most active" subjects in the experiment (The largest number in the column.). Shaded cells in the top panel correspond to the shaded cells in the lower panel.

Table 15.

Numbers of Transactions Terminated by Suspected Rabbits During the First Minute of Each Period.

Experiment#	03	05	06	10	11	13	13	14	26	26	27	28	30
Subject#	00	06	04	03	06	04	05	01	00	04	00	05	02
Period#	Numbers of Transactions Terminated During the First Minute												
1	2	1	1	3		1		1		1	1		
2	3	2		3		1	2	3		2			1
3	3	1	3	3		3	2	3	1	1	2	1	2
4	3	2	3	4	1	1	2	3	1	1		2	2
5	3	1	4	4	3	2	2	3	1	1	4	3	2
6	3	1	4	4	3	2	2	3	1	2	4	4	2
7	2	1	3	4	2	1	3	4	2	3	3	3	2
8	2	3	3	3	2	2	3	3	2	3	4	2	4
9	2		2	4			2	4	2	3	3	3	3
10	1	2	3	2	1	3		3	3	3	2	2	3
11	1	1	3	2	2	2	1	4		4	3	2	4
12	1	1	3	3	2	2		4	1	3	3	2	4
13	0	1	3	3	2	1	1	5		2	4	2	4
14	3	2	2	3	2		2	4	1	2	4	1	4
15	1	3	3	3	1	1		4	2	1	4		5
16	1	2	3	4	1		3	3	3	1	3	1	4
17	1	3	2	4			3	3	2	1	3	1	4
18	3	1	3		2	3		4	4	2	5	2	4
19	2	3	1		3	2		4	4	3	4	1	4

Figure 1: Parameters as Market Demand and Supply

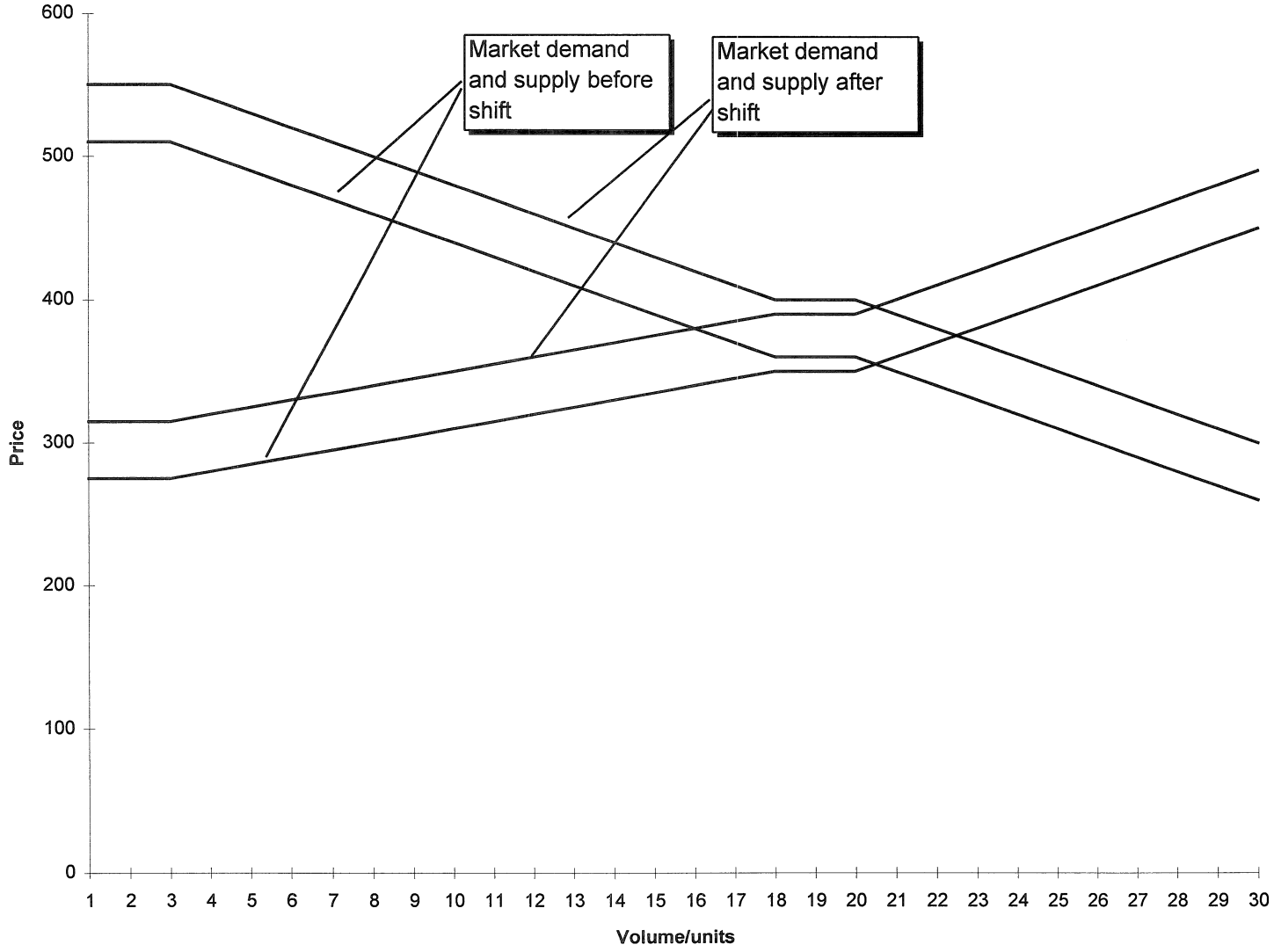

FIGURE 2. EXPERIMENT 02.

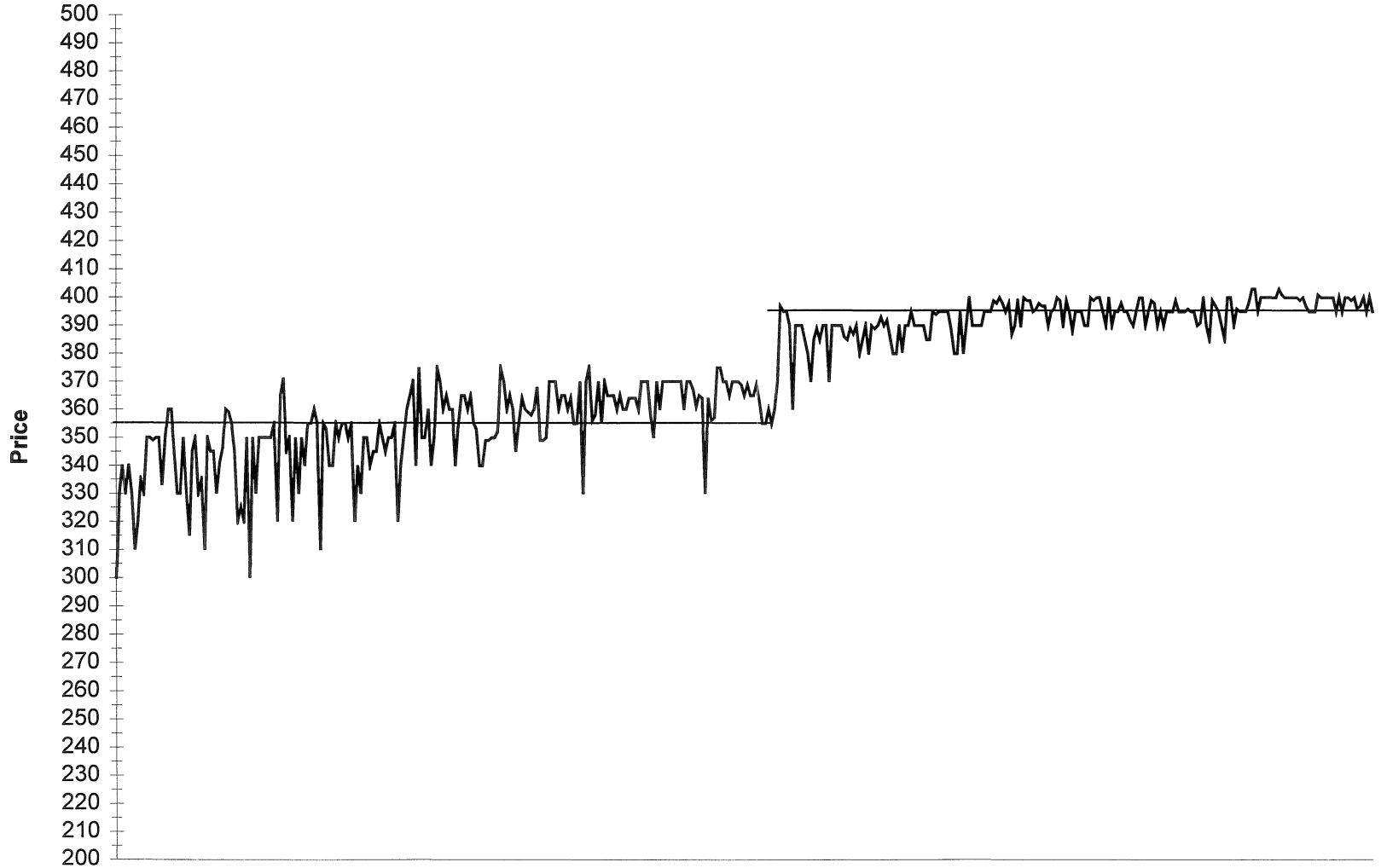

FIGURE 3. EXPERIMENT 03.

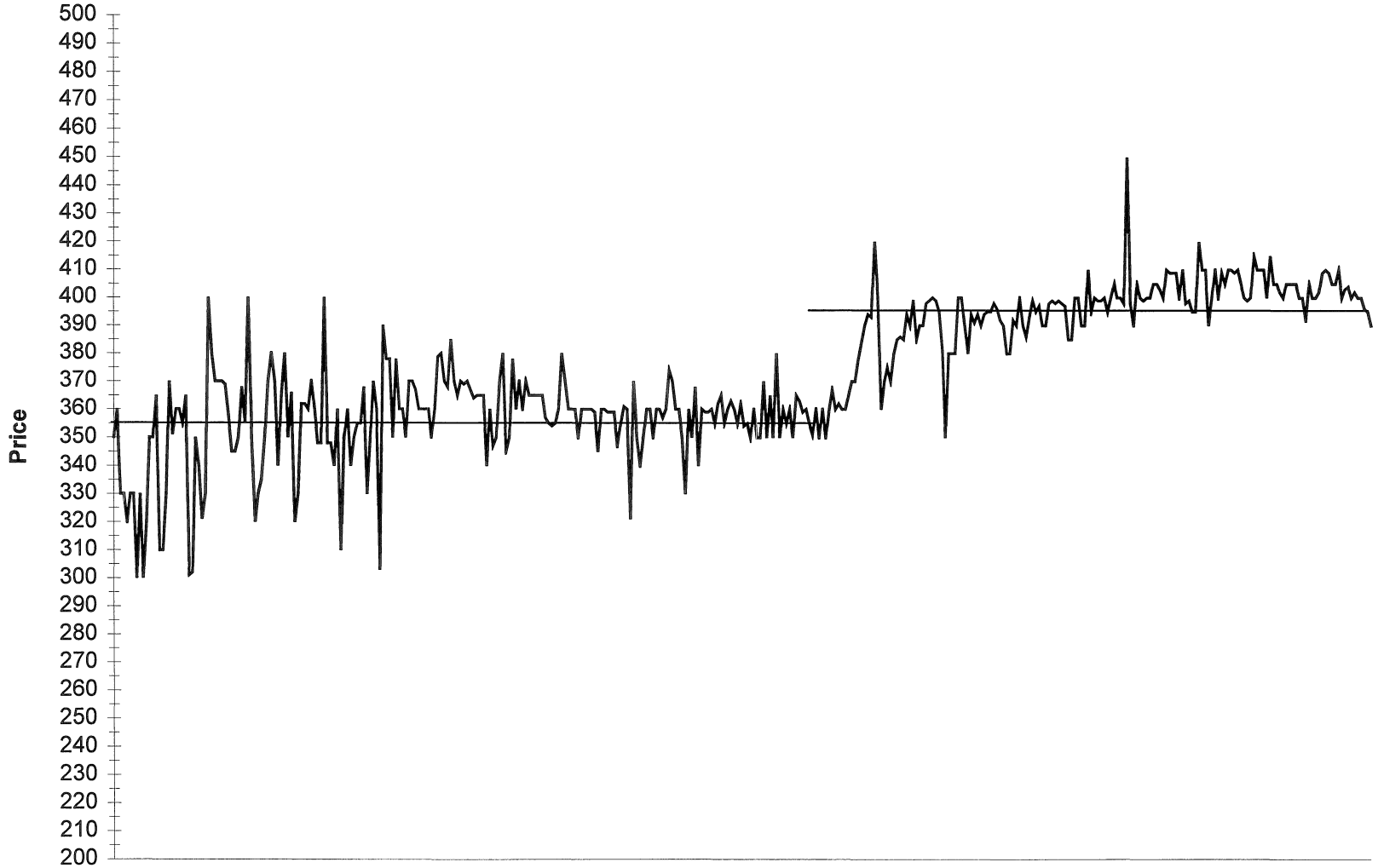

FIGURE 4. EXPERIMENT 05.

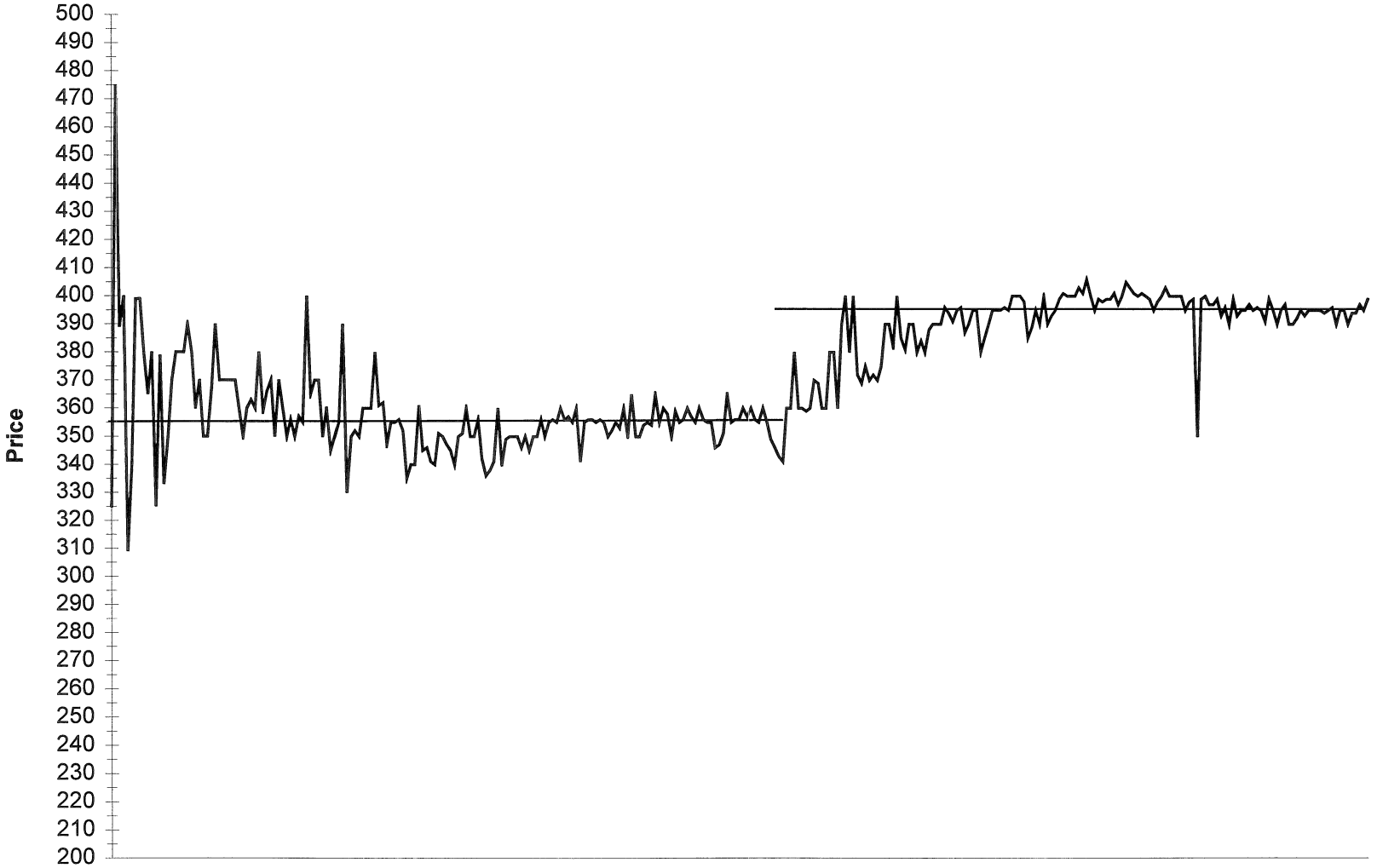

FIGURE 5. EXPERIMENT 06.

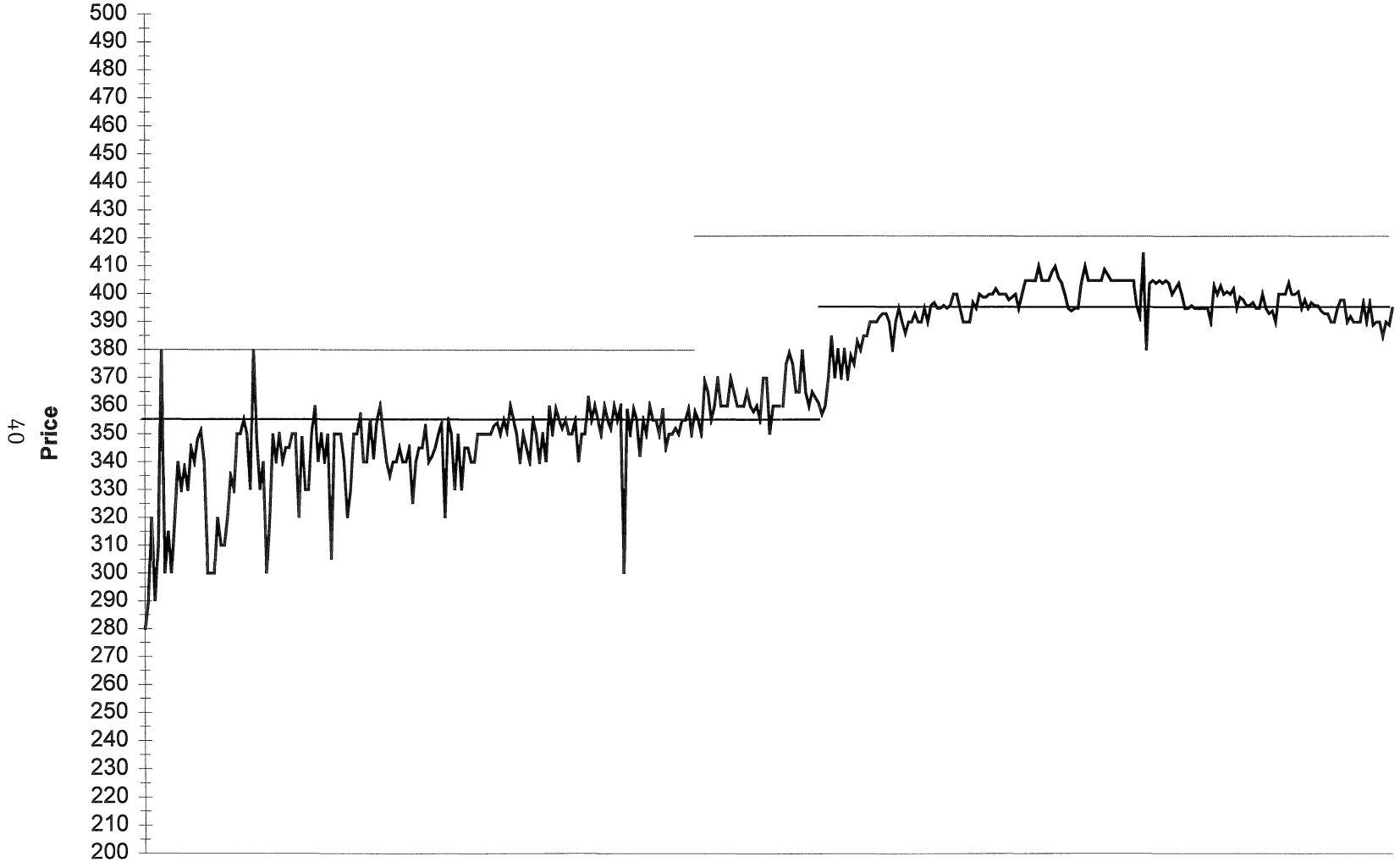

FIGURE 6. EXPERIMENT 10.

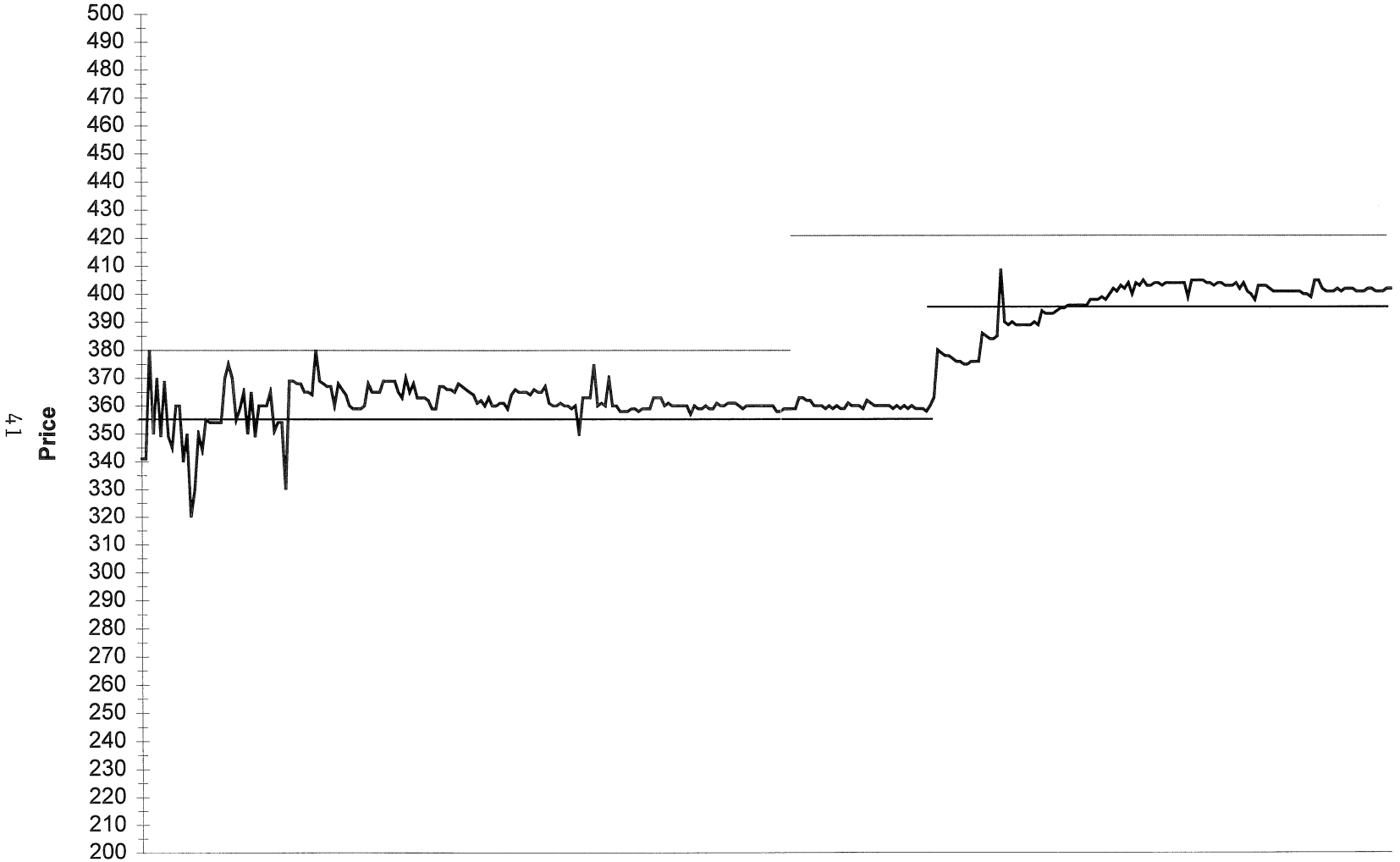

FIGURE 7. EXPERIMENT 11.

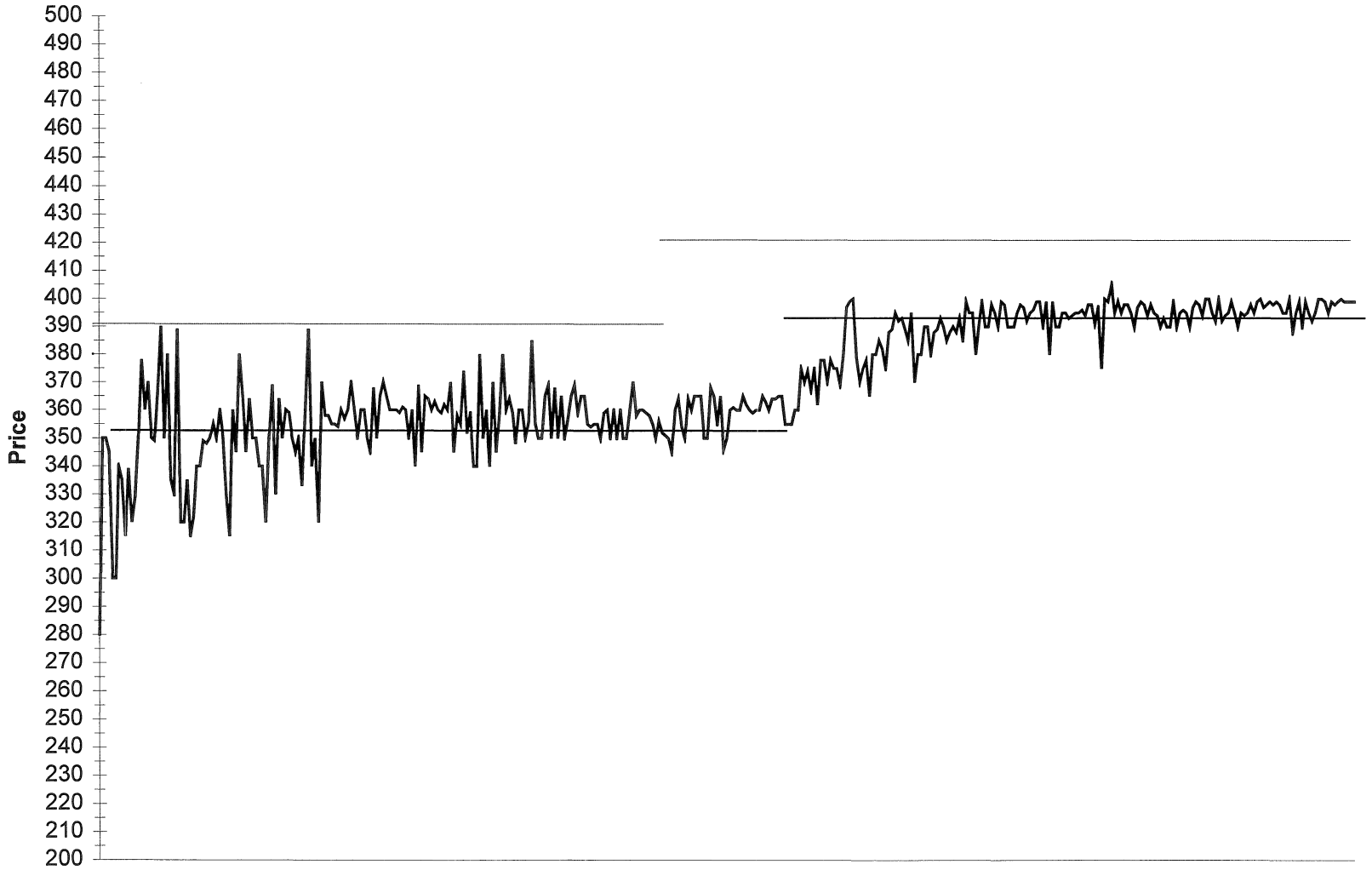

FIGURE 8. EXPERIMENT 13.

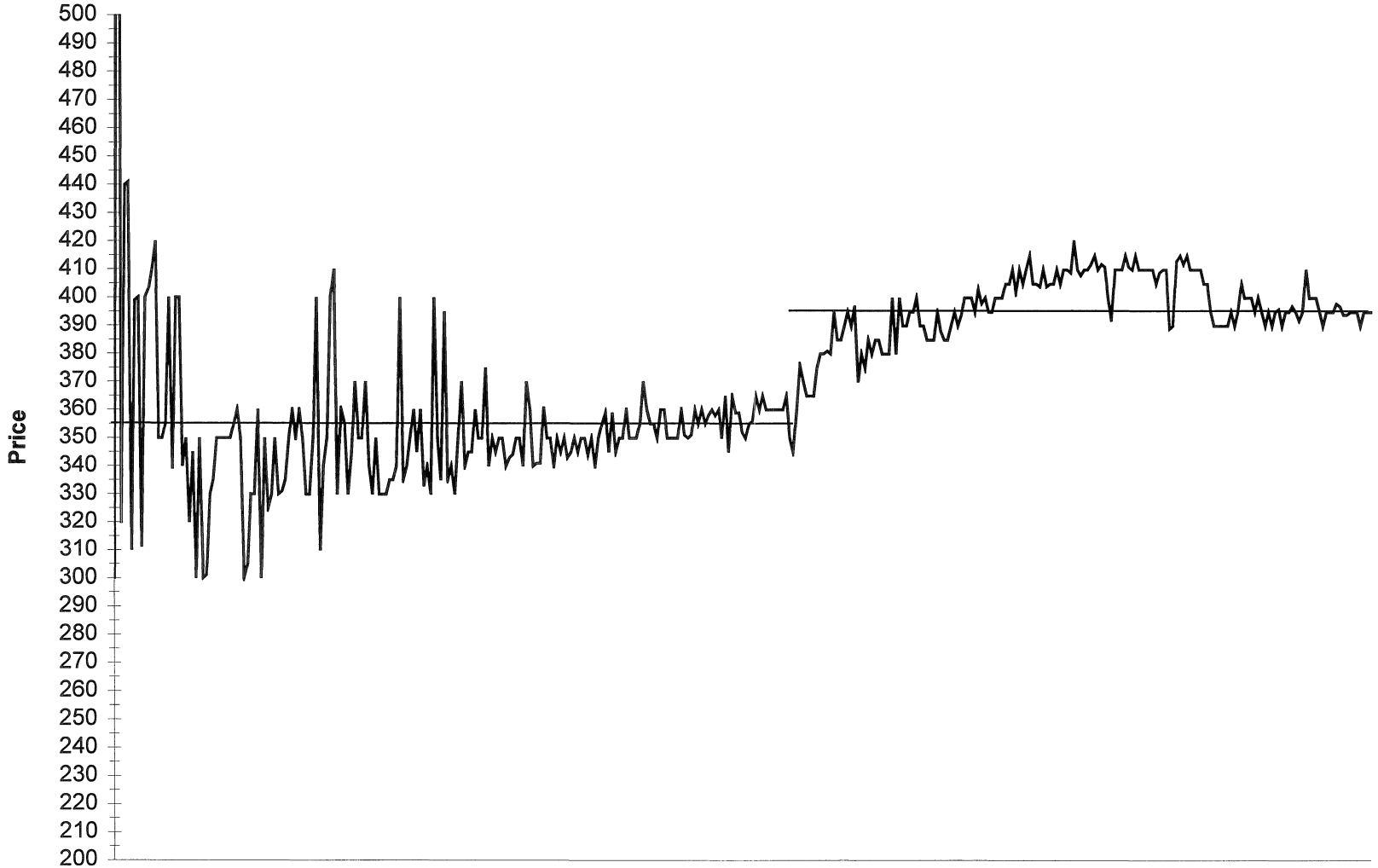

FIGURE 9. EXPERIMENT 14.

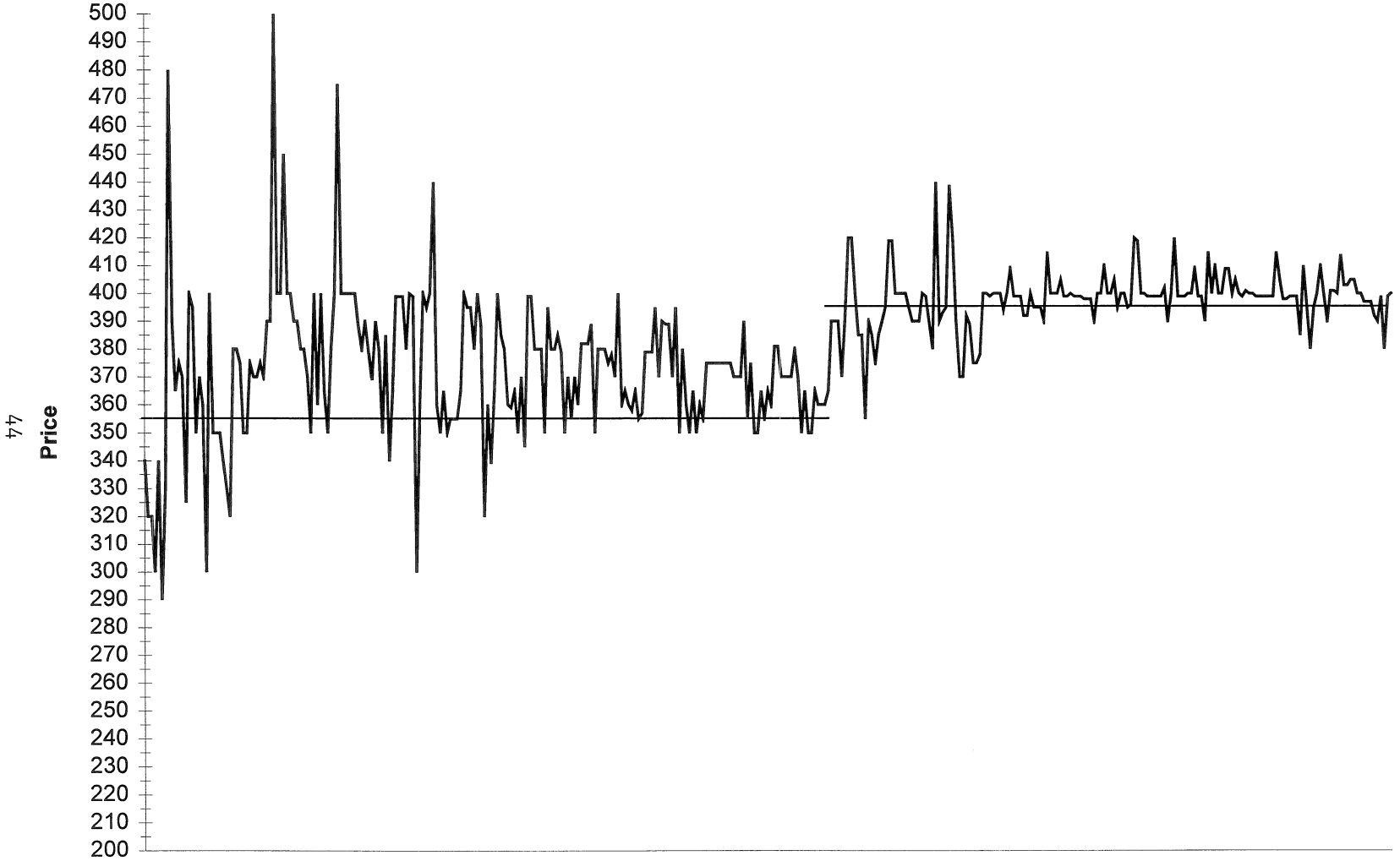

FIGURE 10. EXPERIMENT 25.

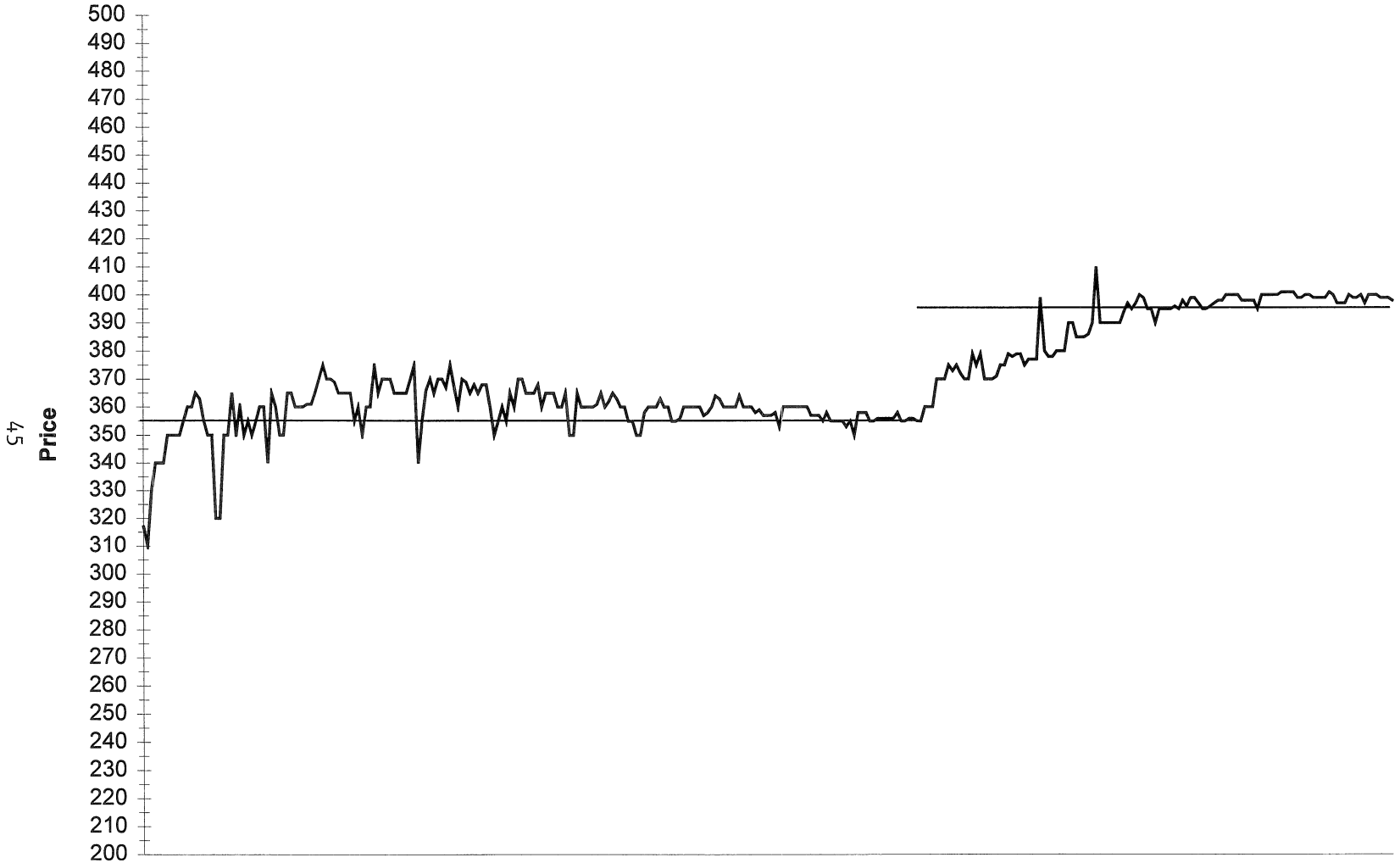

FIGURE 11. EXPERIMENT 26.

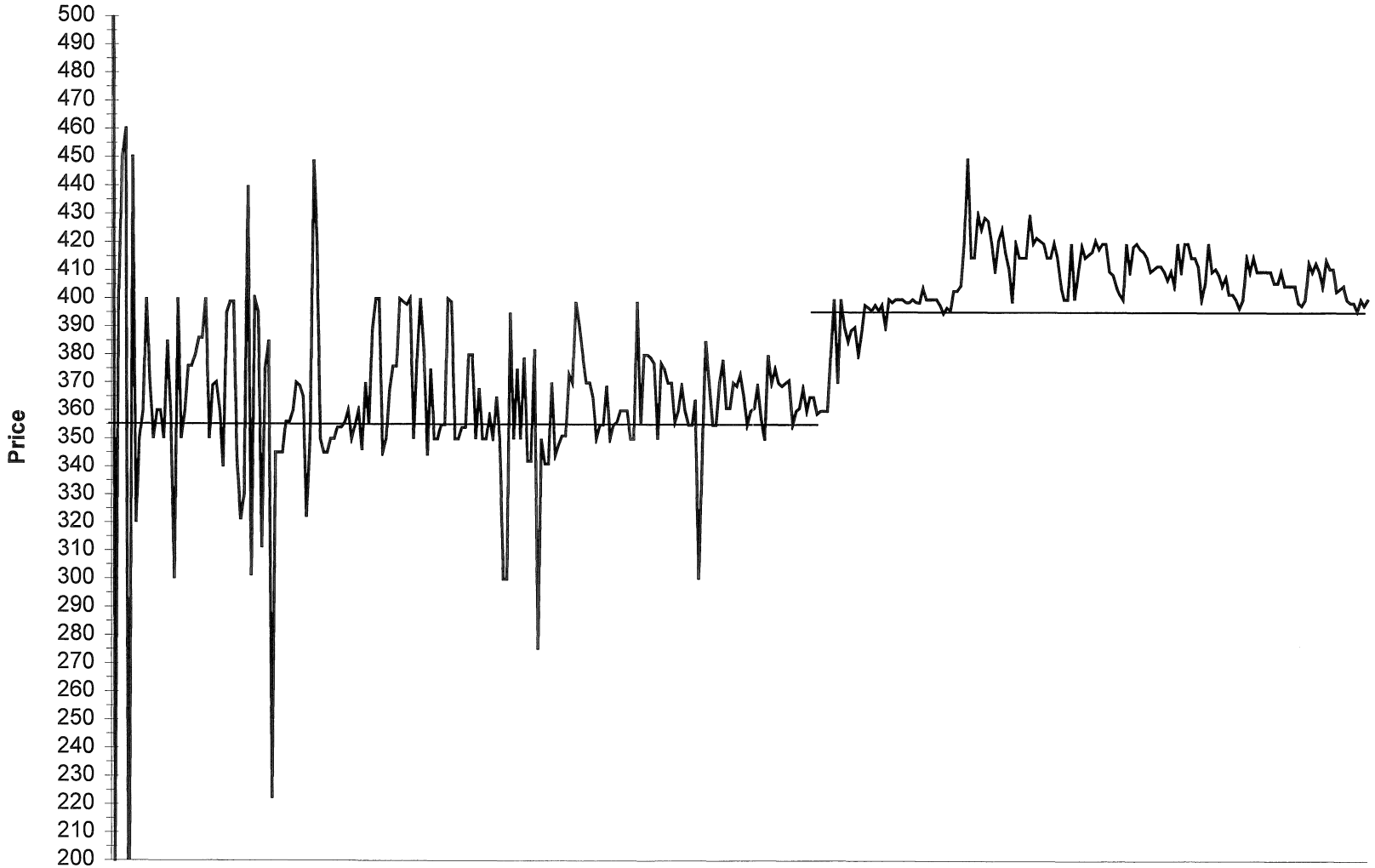

FIGURE 12. EXPERIMENT 27.

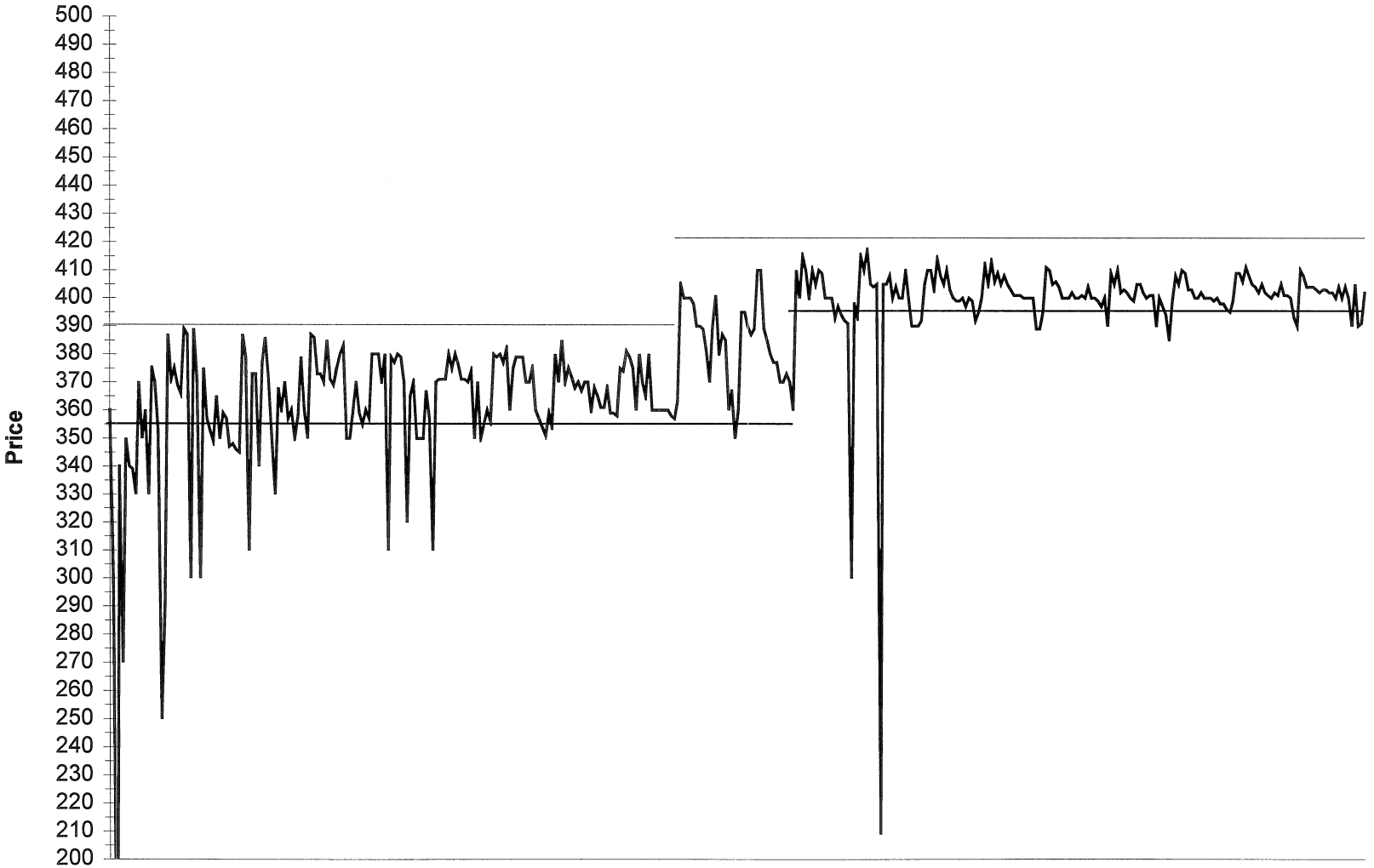

FIGURE 13. EXPERIMENT 28.

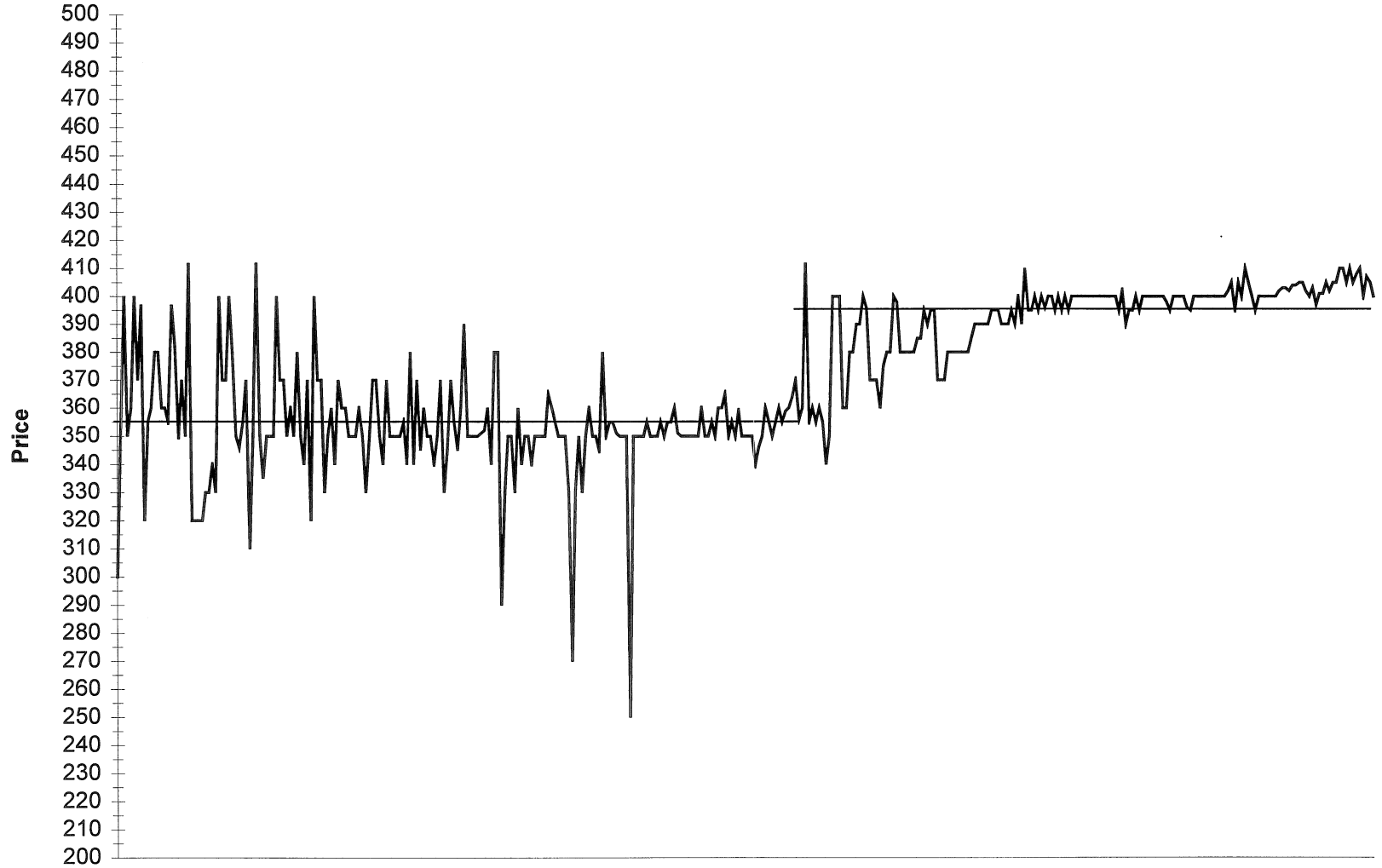

FIGURE 14. EXPERIMENT 30.